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ABSTRACT

Twenty-eight severely and profoundly retarded children (9 to 17 years old) on one unit of a center for the developmentally disabled were taught a nonvocal symbol system based on that developed by D. Premack. Children varied in speech level from totally nonverbal to some who had simple language skills. The symbol system used a behavioral approach involving plastic shapes to represent words of varying degrees of abstractness. A prior pilot study (N=8) had shown that retarded Ss could learn such a nonvocal system. The present study showed that this larger group could also learn, although rate of learning was considerably slower, and amount learned was lower, when Ss' mental ages were at 2 years or below. Twenty-five slow learners with mean mental age of 1.9 learned an average of 10 words over a 6 month training period. Of this group, 13 also learned one and two word sentences, involving verbs. Three fast learners, with mean mental ages about 6 years, learned significantly more words and also combined these words into sentences up to nine words long. Matched control groups of 10 Ss each, on the same and different units, were given equal time, one-to-one interaction, and the opportunity to manipulate analogous material. Neither control nor training groups showed differences pre- and post-training on IQ, MA, or vocalization. However, attention span increased significantly for the training group and decreased significantly for the controls. It was concluded that although there were wide individual differences in learning rate and amount, a nonvocal symbol system can be helpful to permit at least minimal communication where no other mode exists and no other approaches have been feasible. (Author)

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NONVOCAL COMMUNICATION FOR NONVERBAL RETARDED CHILDREN

by

Ruth F. Deich, Ph.D.
Institute for Research in Human Growth
Claremont, California

and

Patricia M. Hodges, Ph.D.
Department of Psychology
California State University
Los Angeles, California

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ABSTRACT

Twenty-eight retarded children on one unit of a center for the developmentally disabled were taught a nonvocal symbol system based on that developed by Premack. Children were moderately to profoundly retarded and varied in speech level from totally nonverbal to some who had simple language skills. The symbol system used a behavioral approach involving plastic shapes to represent words of varying degrees of abstractness. A prior pilot study ($n = 8$) had shown that retarded subjects could learn such a nonvocal system. The present study showed that this larger group could also learn, although rate of learning was considerably slower, and amount learned was lower, when subjects' mental ages were at 2 years or below. Twentyfive slow-learners with such low mental ages learned an average of 10 words over a 6 month training period. Of this group 13 also learned one- and two-word sentences, involving verbs. Three fast learners, with mean mental ages of about 6 years, learned significantly more words ($\bar{X} = 50$), and also combined these words into sentences up to nine words long.

Matched control groups of 10 subjects each, on the same and different units, were given equal time, one-to-one interaction, and the opportunity to manipulate analogous material. Neither control nor training groups showed differences pre- and post-training on IQ, MA, nor vocalization. However attention span increased significantly for the training group and decreased significantly for the controls. It was concluded that, although there were wide individual differences in learning rate and amount, a nonvocal symbol system can be helpful to permit at least minimal communication where no other mode exists and no other approaches have been feasible.

INTRODUCTION

It is universally accepted that language communication is a prime requirement for meaningful human interaction. Mildly to profoundly retarded children often lack any significant language skills, creating frustration for the retarded, as well as for those with whom they interact.

Without the ability to express consent, dissent, needs, emotions, and ideas, individual autonomy is arrested, and emotional frustration results. Children who do not communicate are diagnosed and treated differently than those who do (Baltaxe and Simmons, 1975). If a child communicates, he is more likely to be treated as capable of comprehending, and is provided with greater stimulation and met with more normal expectations. Because the consequences of language deficits are critical to a child's healthy social, emotional, and intellectual development, the need to develop alternative and language stimulation systems is clear.

Emphasis in most remedial programs has naturally been on developing oral communication skills, and such programs have had varying degrees of success. (Berry & Eisenson, 1956; Bricker & Bricker, 1970, Donovan, 1957; Johnson, 1950; Johnson, Brown, Curtis, Edney & Keaster, 1967; Mysack, 1966; Richardson, 1967; Stevens & Heber, 1965; Schiefelbusch, 1967.) Where speech development is not feasible, or has been unsuccessful, nonvocal language training is the goal.

Language treatment programs tend to be shaped by the presenting disability of the child. Sign language is taught to the hearing impaired and has been effective in providing an alternative communication system to this population (Bellugi, 1972; Vernon and Koh, 1970). However, young children with developmental delays often do not have the fine motor coordination required for signing. Signing also requires that short-term memory be well developed since each sign does not stay in view for more than a few seconds. Thus it would have limited benefit for retarded children who are known to have greater difficulties with short-term memory (Graham, 1968).

Children with severe motor impairments resulting from brain damage or cerebral palsy have been offered communication boards, specially equipped typewriters, mechanical devices, and computerized light equipment for alternative communication systems (Vanderheiden and Grilley, 1975). The majority of these techniques are based on the use of the alphabet and require that a person be able to read. Communication systems with arrays of letters and words are generally designed for the individual who does not have use of the speech musculature, and will not be able to produce intelligible verbal speech. However effective use of the communication boards requires reading and comprehension abilities beyond the level of most retarded children.

Another nonvocal technique is the Bliss Symbol System (1973), which involves complex visual pictographs. However they require comprehension of relatively abstract and complex meanings, which again makes such a system beyond the capacity of all but the highest functioning retarded.

In a brief four-month pilot training program, Hodges & Deich (in press), and Deich & Hodges (1975), successfully taught eight nonverbal retarded children to communicate nonvocally with an artificial language system utilizing plastic symbols to represent words. This system was developed by Premack [1970 (a), (b), 1972] who successfully taught a chimpanzee, Sarah, to communicate by means of an artificial language system.

In examining the function of language from the point of view of the proverbial visitor from outer space, Premack analyzed language not into its grammatical components, but in the step-by-step procedure that would be required to teach communication skills to a nonlinguistic organism. Premack used plastic symbols to represent the units of language (words). For the chimp, the effect of using the symbols was to eliminate the vocal demand and focus on skills occurring in the animal's repertoire (visual discrimination and motor responses). The chimp was not required to create a response (word), but could rather select (discriminate) a prepared response (symbol). For Sarah, language was then based on discrimination, association and motor response. The impact of Premack's functional analysis of language upon the field of communication is evident. Of equal importance for those dealing with the nonverbal, severely/profoundly retarded population, is his success in breaking language away from its linguistic framework and analyzing it into separate, discrete steps fully within the low-functioning retardate's pattern of skills (discrimination, associative learning, motor responses).

Glass and Gazzaniga (1973) successfully used the Premack system with previously verbal adult aphasic patients and Carrier [1974, (a), (b); 1975] applied the system to mute retarded children. Blair and Baldwin (1975) utilized our adaptation of the system for a group of autistic children and concluded that the Premack system was no more effective than was a vocal training program. Munsch and Reichert (1976) used our adaptation to teach four nonverbal autistic children, and found that within a five-month training period three of the four learned some words, with varying degrees of abstractness.

These studies differ in the populations used: Glass and Gazzaniga dealt with previously verbal subjects who had lost speech functions, while Blair and Baldwin dealt with autistic children who had some speech. Carrier has been working with retarded children, but neither he, nor Deich & Hodges (1975), used adequate comparison groups to account for the effect of increased individual attention, as against training per se. The present project used comparison groups who received equal amounts of individual attention, thus permitting evaluating the efficacy of using a nonvocal symbol system to establish communication among previous non-communicators.

Since communication is crucial to meaningful human interactions, a system which develops communication skills has practical import and fulfills a real need. Where vocal communication skills are not present, it is necessary to find a technique to rectify this lack. In our prior study noted above, the Premack language system was used successfully to teach nonverbal retarded children to communicate.

The problem with the Deich & Hodges pilot project was that the use of the symbol system was restricted to teacher-child training sessions and neither symbols nor trained persons were available outside of the training time. The aim of the present study was to make symbols available for all on the unit, and to train all children and staff. The aim was to teach them a basic vocabulary of about 100 words which would help them express needs and desires. As will be discussed later the outcome of training was lower than the initial goal because drastic population changes radically lowered the mental ages of children who were trained in the system.

An interesting side effect noted in the authors' pilot project was that several of the children attempted to vocalize after training. Another aim of the present study was to see whether training in a nonvocal symbol system would stimulate vocalizations in nonverbal children. It has long been claimed by some teachers of the deaf that mute hearing children can be stimulated to vocalize through the use of sign language. There is, however, no experimental evidence to support this assertion. Therefore, our study also measured vocalizations and speech levels of all children pre- and post-training.

PROCEDURE

Fifty three institutionalized retarded children from two different units comprised the sample. Thirty three children from unit A comprised the training group who were taught the symbol system. Ten matched controls from the same unit A and ten matched controls from unit B were given an equal amount of attention and comparable manipulation of objects. The rationale for using control groups from the same and different units was to permit comparison of same and different environments, as well as to determine whether the control group on the training unit might incidentally pick up some of the symbol system from their peers.

All children were pre- and post-tested on such variables as mental age, I.Q., speech and attention, knowledge of concepts, and negative and positive behaviors. Other information available included medications, level of vision and hearing, and behavior problems (see CENSUS DATA below). In addition, subjects who were taught the symbol system were measured on amount and speed of learning, as well as retention level.

Assignment to training and control groups on Unit A was random, except for six children who had previously had sign language. These had to be evenly assigned to each group on the basis of MA and speech. Controls in Unit B were matched on MA and speech to subjects on Unit A. Results from the two control groups were later combined because there were no differences in characteristics and behaviors for the two groups.

In all, 4 control subjects (2 from each unit) and 10 training subjects were dropped. The dropped subjects included two who left the institution, 4 who were hospitalized for a long term, one who remained violent despite behavior modification, and the rest were totally unresponsive to the training program. Five new children entered the training group one to two months after training had begun, and 2 new controls were added. Most later analyses therefore concern the retained subjects, 28 training, and 18 controls.

SUBJECT CHARACTERISTICS: (See Table 1)

Originally all children from the two units were to have a minimal mental age of two years since previous research showed that a mental age of two years appeared to be a sufficient minimum for learning this nonvocal language system (Deich and Hodges, 1975). However there was an unexpected and radical change in the population on the two units shortly before the training program began. Consequently most of the children functioned below the mental age of two, with the lowest having a mental age of 11 months and the highest having a mental age of 7 years 6 months. The mean mental age of all subjects for the training group was 2.0, and the mean mental age for the controls was 2.1 years. Difference between the two groups was not significant.

Chronological age ranged from 9 years to 17 years with means of 13.3 and 11.8 years, respectively, for the training and control groups. Age differences between the groups were not significant.

Speech level, as derived from our Speech and Attention test, was similar for the training and control groups with a mean of 2.5 each in expressive language. This level includes the majority who were basically nonverbal (grunts, noises, non-understandable sounds or some unclear words). The others, 4 in the training and 5 in the control groups, were able to communicate in simple words and sentences ranging from unclear to relatively clear.

Receptive language was 2.4 per group. Only 5 subjects were unable to follow any verbal commands. All the rest were able to follow simple commands such as "come here", "sit down", and "give me the pencil".

Speech Level was directly related to rated attentiveness (on the Speech and Attention Test). Thus, those with meaningful speech showed high levels of attention (85% of the time), those with some speech were attentive 67% of the time, and the nonvocal children were attentive about 55% of the time.

None of the children were deaf or blind, but a few had some degree of auditory or visual impairment, and many had behavioral problems including short attention span, little or no relation to others, and aggression against self or others.

PRE- AND POST-TEST MEASURES WHICH WERE INDEPENDENT OF TRAINING:

All subjects were given pre- and post-tests which in nearly all cases were separated by six months of training or attention sessions. In some cases pre- and post-tests were closer due to the changes in population which occurred during training. Five children came in 1 and 2 months after training had begun. On the post-testing there were some who were not followed up since they had left the program, and also a few who were not given post testing, because they had had only a few sessions of training.

Pre- and post-tests included tests of intelligence, speech and attention, concepts, behavioral measures, and ratings of other variables such as hearing, vision, and so forth. Specifically they included the following:

TESTS OF INTELLIGENCE: Originally two tests were projected to be given to all subjects. They were the Peabody Picture Vocabulary Test, PPVT, and the Leiter scale. Both of these tests are designed for use with non-verbal as well as verbal subjects. The PPVT merely requires that the subject point to the appropriate picture out of four on display. Subject must point to the picture which shows the word for concrete and abstract nouns, action verbs and so on, such as table, climbing, or time. This test gives a good index of receptive language. The Leiter tests a somewhat different process, since it is more a measure of conceptual ability. The subject selects and matches without having to be able to speak or hear. Both of these tests were found useful in our pilot project referred to above (Deich and Hodges, 1975). However because of the change in population, with accompanying lower mental ages, some of the subjects could respond neither to the PPVT nor to the Leiter. Both of these tests start at the 2-year level. All children were first given both of these tests. Then those who were unable to attain even a raw score

on the PPVT, and/or could not pass the 2-year level on the Leiter, were given the Kuhlmann-Binet. This test of intelligence, which goes from birth to year two, is heavily slanted towards motor performance, and also gives credit for verbalization. Consequently it is not as adequate a measure as the PPVT and Leiter. However, there is no better, properly validated, and predictive, nonverbal test available below the mental age of two. A few children passed all items on the Kuhlmann-Binet and yet could not perform on the Leiter. They were consequently given the Stanford-Binet test which also is heavily verbally loaded.

Intelligence quotients were thus derived from a number of sources: Leiter Scale, Peabody Picture Vocabulary Test (PPVT), Kuhlmann-Binet (K-B), & Stanford-Binet (S-B). The addition of K-B and S-B was necessary because of the low-mental ages. IQ's are roughly comparable* for these four tests on a group basis. Range of IQ was from 6 to 57, with mean IQ's for the training and control groups being 18 and 25, respectively. Specifically for training and control groups, the mean IQ's were as follows: Leiter Scale = 43 & 41; PPVT = 34 & 23; K-B = 11 & 14; and S-B = 29 & 25. Differences between groups were not significant.

TEST OF SPEECH AND ATTENTION: The test devised by Deich & Hodges for this particular project with the aim of measuring the variety of expressive and receptive language abilities from primitive responses such as grunts, to simple imitations, to spontaneous words and sentences. Rating is according to level and clarity of utterance. Test includes measures of: spontaneous speech; staff ratings on speech level, such as nonverbal, verbal but inappropriate, verbal with meaningful speech, etc.; and measures of attention, including percent of time spent in "sitting at table", "looks at tester", etc. (See Appendix A for sample test). Staff ratings agreed fairly consistently with our ratings on speech level.

VOCALIZATION TESTS: Children's vocalizations were measured by videotape as a pretest. This involved attaching a microphone on a neckband in front of the larnyx to pick up any sounds, or approximations of sounds, the subject might make. Despite piloting, too many mechanical failures intervened. Consequently it was difficult to determine vocalization level, and neither videotape nor throat mike was used as a post-test vocalization measure.

However, the same basic technique was used, once one month after beginning of training, and then again after the end of training. Information obtained was recorded on a cassette only and dispensed with both throat mike and videotape. Since the technique remained the same, pre- and post-training comparisons were still possible. Additionally comparisons were made between the two cassette recordings of vocalization.

The basic technique was as follows: each child was asked to respond to "Do you want a candy (or M&M, etc.)?" Responses were recorded on a cassette, and the level of response was rated according to type of response, from "no vocalization", to "grunts", to "inappropriate response", all the way to "appropriate response". Vocalizations were rated by two different judges, one who knew the child and one who did not. (For further discussion and details on vocalization see RESULTS, III.)

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* Although these tests measure different abilities, they all do give an estimate of MA and hence IQ.

The procedure involved using a "stooge" or model, who sat in a semicircle with 2 children, at a time, who were being tested for vocalization. The "stooge" was a verbal child on the unit. The rater first asked the "stooge": "Johnny (or whatever) do you want this M&M?" If the child(ren) preferred another reinforcer, such as cereal, the question was changed appropriately. The stooge invariably said "yes" to the question, and reached out his hand toward the proper reinforcement. The other two children were then each asked in turn if they would like a candy. They heard the question asked by the teacher, heard the stooge's "yes" and saw him reaching toward the candy. Consequently they basically knew what was required, and would follow as best as they could, in terms of reaching and vocalization, at whatever level they were capable. The stooge served as model for a whole series of children, most of whom were interested, but only some of whom were able to vocalize. This test of vocalization was given one month into the training program, and again at the end of the training program.

CONCEPTS TEST: This test devised by Deich for the previous pilot project, to determine which of a select group of concepts the subject knew in terms of receptive language, i.e., which he understood, and which he was able to respond to correctly. The child had to point to, or select from, differently colored diamonds, squares and triangles, those which were the "same", "different", "smaller", "bigger", "all", and so forth. The aim of the test was to provide comparative data on pre- and post-test changes, if any, of ability to understand the names of concepts, even tho names per se were not taught. An additional goal was to determine whether those subjects, who initially knew more concepts, were able to learn the symbol system at a faster rate than those who knew fewer concepts.

BEHAVIORAL MEASURES TEST: (See Appendix A.) Test devised by Deich for this project to rate certain behaviors applicable to a lower functioning group. The measures include such items as eye contact, independence, cooperation, awareness of others or surroundings, aggression, and self destruction.

Those children who did not have eye contact, or could not sit at a table, were given a training procedure to develop these behaviors. In addition, for children who had behavioral problems such as aggressive or self destructive behaviors, behavior modification programs were instituted to reduce such negative behaviors.

END OF MONTH QUESTIONNAIRE: (Appendix A) At the end of each month each subject was evaluated on a number of variables, such as "responsiveness", "attachment", and "attention span." In terms of a useful, measurable variable, the latter was most viable.

CENSUS DATA: In addition to these tests, further data was culled from annual census data available on such variables as: hearing; vision; ambulation; race; sex; chronological age; medications currently in use; type of handicap; speech levels; self-help skills; and positive and negative adaptive behaviors. Negative adaptive behaviors include items such as violence towards self or others, self-abuse, and destruction of property.

TEACHERS FOR ALL SUBJECTS:

Teachers consisted of paid research assistants, together with volunteers, who were culled from both undergraduate and graduate behavioral science departments. Paid teachers would consistently work with the same children for all, or nearly all, of the months of training, while the volunteers would change every four to six weeks, depending on the time scheduling of the particular colleges from which the volunteers were recruited.

PROCEDURE FOR CONTROLS:

Control groups on units A and B began with the same number of sessions and length of time per session as was given the training group. Controls were given a chance to do similar manipulation of objects as the training group. All were exposed to the same kind of one-to-one interaction and to the same kind of vocalizations. This was to permit comparisons of any post-training differences in vocalization between training and control groups. However, in the last months of the project, hepatitis quarantined unit B and, for a shorter period of time, isolated unit A. Thus Control group B ended up with fewer sessions and less time. (See RESULTS section for further details.)

Teachers rated control subjects after each session on the basis of attention span. This involved rating such behaviors as "keeps body quiet", "sits at table", and "responds to social reinforcement". Overall attention was rated in terms of the length of time the child voluntarily stayed in the session. This rating was in addition to the End-of-Month Questionnaire, which also rated attention.

PROCEDURE FOR TRAINING GROUP, i.e., EXPERIMENTALS:

This group was taught the symbol system of plastic shapes where each shape represents a word. The aim was to teach the child to associate a shape with a word and to learn to write strings of words comprising sentences.

Symbols were placed on a board in left to right order, following English language usage. In effect, symbol placement in this scheme constituted "writing".

SCHEDULING: With the exception of holidays and illness, all children (training and control groups) were seen every day for 35 minutes each throughout the course of the training project. For most children this consisted of 6 months of training. For some, because of illness or later transfer into the program, it may have been as little as 4 months.

MATERIALS: Materials consisted of magnetized plastic symbol shapes, magnatized boards, plastic objects representing real foods, other real objects such as clothes, toy cars, dishes, and balls, as well as food reinforcers of various sorts, such as M&M's, and cereals.

Board and shapes were magnetized, following our previous pilot study and Premack's work with Sarah. However, it was discovered that horizontal placement of the board in most cases eliminated sliding of shapes, and therefore elimirated the need for magnetic strips.

THE SYMBOLS: There were 15 sets of 100 differently shaped plastic forms. These forms are the symbols of the language where, as noted above, each symbol represents not letters, but complete words, and each symbol is the equivalent of a single word or concept. The symbols are color voded according to parts of speech so that red stands for nouns; blue for verbs; green for adjectives; yellow for other parts of speech including pronouns, prepositions, abverbs and conjunctions; and gray for color names. The achromatic, neutral gray was deliberately chosen so as not to confuse the learning of different color names like red, yellow and blue. The aim here was to facilitate learning, if possible, by adding an initial cue -- color -- to the learning process, and leaving it out, in effect, by using gray,where it might be considered a source of interference.

Symbol sizes vary from 1 inch square to 1 x 1/2 inches, to 1 x 2 inches. Width is consistently 1/4 inch. Words were derived from several sources which included: words previously used in the pilot study which were successful at the time, words the staff felt would be helpful for the children; and words which were culled from the dictionary for sign language for the deaf (Bornstein, et al, 1975).

Symbols in the pilot study were nonrepresentational (with two exceptions, the symbols for boy and girl) to avoid confounding the effects of teaching with recognition of previously known objects. In the present training project the aim was to facilitate any potential learning and therefore, wherever possible, symbols for concrete nouns (such as banana, apple, cup) were shaped like the actual object. However, the color of the object would not necessarily be accurate. For example, banana (a noun), was colored red, as were cracker and box (see Appendix D for Symbol Dictionary). All nouns were red, yet red banana, cracker, and chip are clearly not red in real life.

THE OBJECTS: Objects representing foods were good plastic facsimiles such as bananas, oranges, and apples. In addition a cracker was embedded in clear resin so that it would clearly look like a cracker, but at the same time be inedible. These plastic substitutes were necessary because these children, who were mostly at an infantile level of development, usually started to chew on the foods that were to be used as teaching devices. The plastic substitutes were therefore inexpensive and necessary, since they lasted throughout the course of training.

THE BOARD: Symbols were placed on a 12 x 16" framed board. Halfway through training a smaller 6" x 10" board was substituted for the slower learners because it was considered less distracting. The background color was neutral brown (large board) or gray (small board). In a few cases where gray seemed to make it difficult to separate symbol from board, a white sheet of paper was used as the background.

THE TEACHING PROCEDURE: The child sat at a table facing the board whose wide end was parallel to the child. Directly past the board were two or three real objects (like the plastic substitutes for the real foods: apples, bananas, or crackers), and food rewards (such as M&M's, cereals, or whatever else was found reinforcing to a particular child). The symbols to be learned, plus the one which remained unfamiliar, were placed to the left or the right of the board, on the child's preferred and dominant side. The teacher started by tapping the appropriate symbol on the object (for example, apple-symbol on real apple) and then placed the symbol on the board directly in front of the object. Teacher then placed the symbol in the student's hand and moved the child's hand to make the same series of movements. The child, with teacher's guidance, tapped the object, and placed the symbol on the board in front of the object. Since this was a correct move, he/she was given a reward. Initially this was always a food, in addition to verbal reinforcement. Towards the end of training some of the children were happy to accept verbal or other social reinforcement.

Tapping the object was considered an important initial step in order to cue the child to start making the connection between symbol and object. Once the child made this initial connection and learned to know "what goes with what", he had learned the basic rules of the game. At that point tapping was no longer necessary and then was phased out.

Although tapping was phased out, guided trials remained the source of information for the child when a new word was introduced or when a child had to be refamiliarized with a previously learned (and forgotten) symbol.

Correct responses were always rewarded as soon as the child made a response, so that he could associate the reward with the desired response rather than with an irrelevant and/or incorrect one. No rewards were given for incorrect responses.

Although neither expressive nor receptive language was necessary to learn the symbol system, the teacher always talked to the child, naming symbols and sentences, except during the retention tests and where otherwise not allowed, i.e., in those cases where one wanted to test learning level without offering the child any cues besides those he, himself, was able to supply. Speaking to the child put the teaching process in a natural everyday context. To avoid giving cues when they were not allowed, as in the retention test, the teacher gave directions in general terms such as "do what it says here", - "show me how this goes", or made appropriate gestures.

The course of training was based on variations of this technique. The first lesson began by introducing some specific basic nouns and verbs. Subsequent lessons were changed to some extent to fit the needs and the response level of the faster learners who had moved on to the more advanced sessions.

The program's first five learning sets included successively the symbols for: foods (apple, banana, cracker); names (child and teacher); foods (candy, chip, cereal); objects (bowl, box, cup); and action verbs (give and clean). The aim was to teach the child to produce simple sentences early in the learning process.

LEARNING CRITERIA: The child had to correctly select each symbol on his own, and without guidance, 8 out of 10 trials in succession before advancing to a new symbol. As soon as he met the criterion for learning one word or one lesson, he then went on the next word or lesson. Since the words in the first lesson were used in later lessons, the child was later able to get additional practice with earlier words. Between lessons interim retention tests were given to make sure that he had learned the lesson, and had remembered it as well.

If the child failed at some point in the sequence of learning, or retention, previous steps were repeated until success was achieved. There were times when the teacher had to improvise when a specific sequence did not seem to work with a particular child. This is spelled out in further detail below.

The goal was to permit the child to communicate, and to do so spontaneously. Hence if he wished to make up his own sentence, he was allowed to do so. Furthermore, there were certain sections throughout learning where such spontaneous sentence creation was deliberately encouraged. (See Appendix C.)

PROBLEMS AND VARIATIONS DURING TRAINING:

The above outlines the general procedure, but variations had to be devised for a variety of reasons: the low functioning of the majority of the children; the distinctly faster learning rate of three of them; the very real behavior problems of some; and the lack of comprehension and flexibility on the part of many of the retarded. Consequently we had to change some techniques for specific children, and actually add other types of assessments and teaching devices to spur the learning process.

(1) For example, some of the children were totally unresponsive, either by refusing to manipulate the symbols at all, or by hunting symbols and objects at random, despite teacher's guides. These children were therefore not considered ready for direct symbol training and were placed instead in a Pre-Symbol Training Program. The Pre-Symbol Training Program was tailored to the individual child's needs, which included teaching grasping behaviors, eye contact, sitting still at a table, learning to imitate teacher's movements, and, in general, learning to pay attention to the task at hand. Once the child was able to follow placing behaviors, or was able to carry out other simple tasks, he was then placed back in the regular symbol training program or in the Match-to-Sample program. (See Appendix B for Pre-Symbol Training Form.)

(2) Some of the children were unable to understand the demands of the task initially and yet did not need pre-symbol training, because they seemed sufficiently attentive and motivated to warrant training directly on the symbol system. In those cases a Match-to-Sample technique was devised. The aim here was to determine whether the child could actually discriminate the apple-symbol from the banana-symbol. In order to test for, or to teach, this discrimination, the three symbols for apple, banana, and cracker were placed at the far end of the board. Another apple-symbol was then placed close to the subject who was asked, or guided, to place this second apple-symbol on top of the first apple-symbol. Order of symbols was randomized and the child was given a number of trials. The child had to be able to place correctly, and without guidance, the second apple-symbol on the first apple-symbol, to a criterion of two out of three times. After success at this type of matching, the duplicate apple-symbol was placed at the far end of the board while the three symbols for apple, banana, and cracker were placed close to the subject. In this case the subject had to choose the apple-symbol from among the 3 symbols and again place it on top of (or close to the other apple-symbol, if there was a motor problem) the other apple-symbol. This was repeated for the

banana-symbol and then for the cracker-symbol. Once the subject was able to demonstrate this facility in Matching-to-Sample, the direct teaching of the symbol system could begin, i.e., learning to make the connection between the symbol and the real object.

(3) Three children learned the symbol system much faster than the rest of the group. Their rate of acquisition and skill in using the system made it necessary to consider them as a special group (henceforth referred to as the "fast learners"). Due to a mixup in symbol production some of the symbols scheduled for early lessons were not available at the time the fast learners were ready for them, and it was necessary to substitute later lesson symbols for these children. Therefore the order of symbol learning for the first few lessons was not the same for the fast children as for the remaining 25 "slow learners".

The fast children also preferred different kinds of reinforcements, although to some extent they still enjoyed food rewards. Thus they preferred to work for a small candy bar given out at the end of a session rather than to work for continuous small food reinforcers on every correct trial; or they would work for a series of stars drawn on a sheet of paper, which could ultimately be turned in for a small and cheap toy.

SPECIFIC PROCEDURES:

The detailed lessons below give examples of the specific procedures that were followed to teach nouns and verbs. The procedures look relatively straightforward and were followed in general. However there were some changes between the beginning, middle, and end of training for the slower training group. In addition, the fast learners used a somewhat different format, partly because, as noted above, not all symbols were available at the beginning of training, partly because they were able to side-step some of the many sub-steps required for the slower group, and partly because they had no trouble learning verbs. (The specific order of learning may be seen in Appendix E.) Retention tests were also different for fast and slow learners.

Shifts in procedures included the addition of teaching subjects to connect not only symbol to object, but also object to symbol. This step was inserted when it was found that some of the slow learners could not make this shift by themselves.

The initial plan was to begin to teach the verbs give and clean by the fourth lesson. This design meant that simple sentences could be constructed relatively early. The fast learners had no trouble with this approach, but many of the slow learners did. Consequently lesson 4 was used to teach these slow learners one more set of nouns (ball, box and cup) to consolidate, and generalize, a variety of nouns. Lesson 5 then became the verb lesson for the slow learners. We started with the verbs clean and give, and used the same technique that had been successfully used in the pilot study. This involved teaching the verbs in the framework of a sentence with subject, verb, and object. This worked well with the fast learners, but was too complex for the slow ones. When the clean and give learning problem originally became evident in these slow subjects, we thought it was the clean/give pairing which created the problem. Hence we went on to the next lesson set which was insert and eat. Since this particular pairing also created confusion, we then went back to the give/clean pair and decided to simplify the procedure considerably. Analysis of the verb lesson suggested that here the child was presented with an essentially new series of tasks presented simultaneously: (1) he had to learn verbs which were less concrete than the visible, touchable, real object,

nouns; (2) he was suddenly faced with a sentence containing a string of words, whereas before he had merely to respond to one word. Consequently, the teaching procedure was greatly simplified, and the lesson was presented in graduated stages going from simple one-word verb presentations to combinations of two, three, and four words. In effect then, the details of lesson 5 presented below, apply to the slow learners, while the fast learners were presented with the 4-word sentence without the requirement of intervening one-, two- and three-word steps.

DETAILED PROCEDURES ON LESSONS:

LESSON 1: In the first lesson child learned three food names: apple, banana, and cracker. As noted before, the "real" apple and banana were good plastic representations and the real cracker was embedded in clear resin, so that they would not be eaten during the training sessions.

The real objects (banana, apple, and cracker) were placed behind the board in the left, middle, and right positions, respectively.

Four symbols --- apple, banana, cracker, and an unknown noun --- were placed to one side of the board. As noted above, placement was to the left if child was left-handed, and to the right if child was right-handed.

A. Learning to choose the symbols apple, banana, and cracker. Since the learning criterion was 8 correct responses out of ten consecutive trials, some subjects became bored with so many repetitions. In that case the teacher repeated only part of the trials on each symbol at that time, and returned to finish that symbol later.

1. Teacher selected the apple-symbol from the four symbols next to the board and tapped the apple with the symbol. The symbol was then placed on the board directly in front of the real apple. This represented the demonstration trial.

2. A guided trial followed: the teacher then: gave the child the apple-symbol; moved his hand to the apple; guided him to tap the apple three times, and then to place the symbol on the board in front of the real apple. Child was then rewarded with a food reward. Note: All guided trials, because they were by definition correct, were always rewarded.

3. Steps #1 and #2 were repeated for 10 trials. Whenever the child made the proper motions before the 10 trials were up, he was allowed to do so.

4. Teacher next put the apple-symbol back with the other three symbols by the side of the board. He pointed to the real apple and to the symbols, and prompted the child (by means of gestures and speech) to place the correct symbol in front of the apple. Child was rewarded if and only if he did this correctly. During this step the tapping of the symbol on the real object was gradually faded out and was not used in subsequent lessons.

5. Whenever child could not correctly select the apple-symbol and correctly place it in front of the real apple, steps #1 and #2 were repeated.

6. Step #4 was repeated for a total of 10 trials and the child had to carry out the task correctly on 8 or more of these trials to meet the criterion of learning for apple. Here the teacher could give no hints nor cues. Whenever child did not meet the criterion in the first 10 trials, more trials were given until criterion was met, i.e., any 10 consecutive trials which did not contain guide or demonstration trials.

7. Steps 1-6 were repeated, substituting the banana and the banana-symbol for the apple and the apple-symbol.

8. Steps 1-6 were repeated, substituting the cracker and the cracker-symbol for the apple and the apple-symbol.

B. Lesson Retention Test. Each step of the Lesson Retention Test was repeated only once, whether child was correct or not. Lesson #1 was considered passed if four or more of the six test items were correct. In that case he went on the next lesson. If however he was right for less than four out of six items, then he had to go through a Shift-Learning Procedure as in Lesson #1, C, below.

1. Teacher changed the objects' positions so that the apple was on the left, the cracker in the middle, and the banana on the right.

2. Teacher shook the 4 symbols in his/her hands and dropped them to the side of child's dominant hand. This randomly changed the positions of the symbols, and prevented the child from responding to position cues rather than to the symbols themselves. Symbols were always randomized in this manner, whenever child was choosing symbols.

3. Teacher pointed to the banana, and gestured child to find the banana-symbol and place it in front of the banana. If child did this correctly he was given a reward. Teacher then put the symbol back with the other symbols.

4. Same as step 3, but substituting cracker for banana.

5. Same as step 3, but substituting apple for banana.

6. Teacher again changed food placement, with the cracker on the left, the banana in the middle, and the apple on the right.

7. Teacher pointed to the cracker-symbol and gestured child to put it on the board in front of the real cracker. If child did this correctly, he was rewarded.

8. Same as step 7, substituting apple for cracker.

9. Same as step 7, substituting banana for cracker.

C. Shift learning: This was given to children who could not pass the Lesson Retention Test. Its purpose was to eliminate the tendency to repeat the last correct response, which frequently happened with many of the children. The solution was to give fewer consecutive trials of each type. The order of the objects behind the board again was apple, cracker, banana.

1. Teacher pointed to banana. Child had to choose the banana-symbol and place it on the board in front of the banana on at least two out of three consecutive trials.

2. Same as step 1, but cracker was substituted for banana.

3. Same as step 1, but apple was substituted for banana.

4. Steps 1-3 were repeated using a criterion of one correct response rhather than two out of three.

D. Further Lesson Retention Test for Part C. Another retention test was then given after C above, in the same manner as part B. If the child passed, i.e., four or more correct responses, he then graduated to the next lesson. If he did not pass, he was then given parts E & F.

E. Learning to choose objects. Here child was taught to choose the correct object when given the symbol. The criterion of success was four correct responses out of five trials. Since the child chose among different objects, the order of the objects was always changed after each trial, in the same way as the positions of the symbols were randomized when the child was choosing symbols.

1. Teacher placed the apple-symbol on the board and guided child to pick up the real apple and set it on the board next to the apple-symbol. Child was then rewarded.

2. Teacher again placed the apple-symbol on the board, and then prompted child, with words and gestures, to put the apple on the board next to it. Whenever child could not do this correctly, step 1 is repeated.

3. Step 2 was repeated for a total of 5 trials. Child had to carry out the task correctly on at least 4 of these trials and all correct responses were rewarded.

4. Steps 1-3 were repeated using the banana-symbol.

5. Steps 1-3 were repeated using the cracker-symbol.

F. Lesson Retention Test for Part E. In this retention test, child had to choose the symbol on the first three trials and the object on the last three trials. Each step was repeated only once, regardless whether child was correct or not. If child got four or more of the items correct, he then graduated to the next lesson. If child got fewer than four items correct, he then was given part G.

1. The order of the objects was, from left to right, apple, cracker, banana. Teacher pointed to the banana, and prompted child to choose a symbol and place it on the board. If child chose the banana-symbol, child was rewarded.

2. Step 1 was repeated but using the cracker-symbol.

3. Step 1 was repeated but using the apple-symbol.

4. Teacher then changed the positions of the objects, placed the cracker-symbol on the board, and gestured to child to choose an object and place it on the board. If child correctly chose the cracker he was rewarded.

5. Step 4 was repeated but using the apple-symbol.

6. Step 4 was repeated but using the banana-symbol.

G. Shift Learning if failure in F: Here child was given practice both in choosing symbols and in choosing objects. The aim was to have child shift among the symbols and objects in order to eliminate or reduce the child's tendency to perseverate.

1. Teacher placed the objects behind the tray in the order of: banana, apple, cracker. Teacher then pointed to the apple, and prompted child to choose a symbol. This step was repeated until child gave a correct response on at least two out of three consecutive trials (all correct responses were rewarded). Again all symbol positions were changed after each trial.

2. Step 1 was repeated but substituting the banana-symbol.

3. Step 1 was repeated but substituting the cracker-symbol.

4. Steps 1-3 were repeated using a criterion of success of one correct trial rather than 2 out of 3.

5. Teacher then changed the positions of the objects behind the board, placed the apple-symbol on the board, and gestured to child to choose an object. As usual, correct choices were rewarded. This step was repeated until child achieved two correct responses out of three trials.

6. Step 5 was repeated substituting the banana-symbol.

7. Step 5 was repeated substituting the cracker-symbol.

8. Steps 5-8 were repeated using a criterion of success of one correct trial rather than 2 out of 3.

H. Lesson Retention Test for Part G: Part F Retention Test was repeated here. If child passed (4 or more correct), he graduated to the next lesson. If he did not pass, part G was repeated. Parts G and F were repeated here until child passed this retention test and could then go on to the next lesson.

LESSON 2: In Lesson 2 the child learned the words for child and teacher. The format of this lesson was the same as that of Lesson 1. The symbols needed for this lesson were teacher, child, and one unfamiliar noun. No objects were required nor used.

A. Learning to choose the symbols child and teacher. The criterion for learning was again 8 out of 10 correct. Again where the child became bored doing 10 repetitions of one step the teacher would alternate between the symbols until the criterion for each symbol was met.

1. Teacher selected the teacher-symbol from the three symbols next to the board and tapped him/herself with the symbol. Teacher then placed the symbol on the board.

2. Teacher gave child the teacher-symbol, and guided child to tap the teacher and place the symbol on the board. Child was then rewarded.

3. Steps 1 and 2 were repeated for a total of 10 trials, or until the child began making the correct motions alone.

4. The teacher-symbol was put back with the other two symbols on the side of the board. Teacher pointed to self and, by gestures and speech, prompted child to choose the teacher-symbol and place it on the board. Child was rewarded if and only if child did this correctly.

5. Whenever child could not select the teacher-symbol correctly and place it on the board, steps 1 and 2 were repeated. Otherwise, step 4 was repeated until child made 8 correct responses out of 10 trials, with no hints or cues from teacher.

6. Steps 1-5 were repeated, substituting the child-symbol for the teacher-symbol.

NOTE: Because it was initially successful in the pilot project, the technique for learning teacher and child symbol was originally to have these symbols around the neck of the appropriate person. However, we found after some trials, that tapping the person was easier and made for a faster association between symbol and person.

B. Lesson Retention Test. Child had to respond only once to each test item. If child passed he graduated to next lesson. Criterion for passing retention was 6 or more correct responses out of 10 trials. If child failed to meet this criterion, he then had to go to part C, below, Shift Learning.

1. Teacher randomized the position of the symbols.

2. Teacher pointed to self and gestured to child to choose a symbol. Child was rewarded if the choice was correct.

3. Teacher pointed to child and gestured to child to choose a symbol. If child was correct, he was rewarded.

4. Same as step 2 (teacher).

5. Same as step 2 (teacher).

6. Same as step 3 (child).

7. Same as step 3 (child).

8. Same as step 3 (child).

9. Same as step 2 (teacher).

C. Shift Learning (given if failure on B above). Here child had to choose the correct symbol.

1. Teacher pointed to self and child had to choose the teacher-symbol and place it on the board. Child had to respond correctly for two out of three trials.

2. Teacher pointed to child and child had to choose the child-symbol and place it on the board. Again child had to meet the 2 out of 3 criterion.

3. Steps 1 and 2 were repeated using a criterion of 1 correct rather than 2 out of 3.

D. Lesson Retention Test given after Part C: Same test as in Part B was given here. If child passed, he graduated to the next lesson, #3. If he did not, he then was given Part E.

E. Learning to choose the correct person when given the symbol (given if failure on D, above).

1. Teacher placed teacher-symbol on board and then guided child to tap or point to Teacher. This was repeated until child began to make the correct motions without teacher's guidance.

2. Teacher placed teacher-symbol on the board and prompted child to tap or point to Teacher. If child did this correctly, he was rewarded. If he failed, step #1 was repeated.

3. Step #2 was repeated until child met the criterion of four correct responses out of five consecutive trials.

4. Steps 1-3 were repeated, substituting the child-symbol for the teacher-symbol.

F. Lesson Retention Test given after Part E: In this retention test child had to choose the symbol on half of the trials and choose the person corresponding to the symbol on the other half. As usual, each trial was given only once, regardless of whether child was correct or not. A passing score was 6 or more correct responses out of 10 trials. If the child passed he went on to the next lesson. If not he was given further practice in Part G.

1. After randomizing the positions of the symbols, Teacher pointed to self and gestured to child to choose a symbol. If child chose the teacher-symbol he was rewarded.

2. Teacher pointed to child and gestured to child to choose a symbol. If child chose correctly he was rewarded.

3. Same as step 2 (child).

4. Same as step 1 (teacher).

5. Teacher put child-symbol on board and prompted child to tap or point to someone. If child pointed to himself, he was rewarded.

6. Teacher put teacher-symbol on board and prompted child to tap or point to someone. Again if child pointed correctly, he was rewarded.

7. Same as step 6 (teacher).

8. Same as step 5 (child).

G. Shift learning (if failure in Part F). In this section child was given practice both on choosing the symbol when told the person and in choosing the person when shown the symbol. Here child had to learn to shift between the different symbols. The criterion of success was reduced first to two out of three correct, and then to one correct.

1. Teacher pointed to self and prompted child to choose a symbol. (The positions of the symbols were randomly changed after each trial.) This was repeated until child made two correct responses out of three trials, with no guidance from the teacher.

2. Teacher pointed to child. Child had to select the child-symbol and place it on the board. This step was repeated to a criterion of two out of three correct responses.

3. Steps 1 and 2 were repeated to a criterion of 1 correct response.

4. Teacher put teacher-symbol on the board, and gestured to child to point to the correct person. This was repeated until child made two correct responses out of three trials.

5. Teacher put child-symbol on the board. Child had to point to him/herself, to a criterion of two out of three correct responses.

6. Steps 4 and 5 were repeated using a criterion of 1 correct response rather than 2 out of 3.

H. Lesson Retention Test (given after Part G). Retention test outlined in Part F was repeated. If child passed, he went on to next lesson. If he did not pass he had to repeat Part G.

LESSON 3: The names for three foods, candy, chip, and cereal, were taught in this lesson. The procedures for teaching these words were identical to those used in the first lesson except of course that tapping was no longer used.

The real objects, plastic bags containing candy, potato chips, and cereal, were placed behind the board. Four symbols were used: the names for the three foods, plus one unfamiliar noun.

LESSON 4: The words learned in this lesson were ball, box, and cup. The procedures were the same as those in lessons #1 and 3.

LESSON 5:* Here child began to learn the first verbs, give and clean, and began to read and produce sentences. In the first section of the lesson the verbs were used as one-word commands, and child learned to respond with the actions of giving or cleaning an object. In the second section two-word sentences (verb plus object) were used, and in the third section child learned to work with complete sentences, including subject and indirect object.

The symbols needed for this lesson were: child, teacher, ball, box, cup, clean, give, and one unfamiliar verb. The objects needed were: a ball, a box, and a cup, plus a small cloth used for cleaning the objects.

A. Learning one-word commands. The objects and the cloth were placed behind the tray. The three objects were used at random in the sentences wherever the instructions called for "an object." Teacher never used a particular verb-object pair in preference to any others (e.g., clean and cup) since this would have given child an extraneous clue about the correct action to follow.

1. Teacher placed the clean-symbol on the board with one of the objects to its right. Teacher then guided child through the motions of cleaning the object, and rewarded child for doing so. Teacher continued to guide child through the cleaning motions until child began to do them on his/her own.

2. Teacher placed the clean-symbol on the board with one of the objects to its right. Child had to clean that object with the cloth in order to get a reward. This was repeated until child responded correctly on four out of five consecutive trials (with no hints from Teacher).

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* This was the revised version for the slow-learning group. Fast learners succeeded with the original version which had fewer substeps. (See Appendix C.)

3. Teacher placed the give-symbol on the board with one of the objects on its right, and guided child through the motions of giving that object to Teacher. Child was guided for as many trials as necessary for him to do the motions alone.

4. Teacher placed the give-symbol and an object on the board. Child had to give that object to teacher on four trials out of five.

5. Same as step 2 (for a total of 8 out of 10 correct on the command clean).

6. Same as step 4 (for a total of 8 out of 10 correct on the command give).

B. Lesson Retention Test. The cloth was available to child throughout the test. Teacher always had to be aware not to give any hints to child either by speech or by gesture. Each test item was given only once regardless of whether child's response was correct or not. All correct responses were rewarded. A passing score was six or more correct responses. If child passed, he went on to Part I (Two-word sentences). If child did not pass, he went on to Part C (Shift-Learning in following written commands).

1. Teacher put the clean-symbol and an object on the board. Child had to clean the object.

2. Same as step 1 (using a different object).

3. Teacher placed the give-symbol and an object on the board. Child had to give the object to teacher.

4. Same as step 1: (combined clean-symbol with a different object on the board).

5. Same as step 3: (give-symbol and different object).

6. Same as step 3: (give-symbol and different object).

7. Same as step 1: (clean symbol and different object).

8. Same as step 3: (give-symbol and different object).

C. Shift Learning on following written commands (given if child failed Part B).

1. Teacher put clean-symbol and an object (ball, box, or cup) on the board. Child had to clean the object. Teacher guided child whenever necessary, but the criterion (2 correct trials out of three) had to be met with no intervening guided trials.

2. Teacher put the give-symbol and on object on the board. Child had to give the object to teacher. The criterion of success again was 2 correct trials out of 3.

3. Same as step 1.

4. Same as step 2.

5. Steps 1-4 were repeated but criterion was reduced to one correct response.

D. Lesson Retention Test following Part C: Lesson Retention Test from Part B was repeated here. If child passed (6 or more correct) he went on to two-word sentences (Part I). If child did not pass, he had to go on to Part E (learning to choose the symbol corresponding to an action).

E. Learning to choose the symbol corresponding to an action. Three symbols, give, clean, and an unfamiliar verb, were available for child to choose.

1. Teacher placed an object on the board, and told or gestured to child to clean the object. After child has done so, teacher put the three symbols next to the board and asked child to choose a symbol. If child chose the clean-symbol he was rewarded. Sometimes it was necessary to guide the child in choosing the symbol at first. The criterion of success was four correct choices out of five trials (with no hints or guides by teacher).

2. Same as step 1, but substituting the give-symbol.

3. Same as step 1.

4. Same as step 1, again substituting the give-symbol.

F. Lesson Retention Test following Part E: Lesson Retention Test from Part B was repeated here. If child passed he went on to the next lesson. If child failed, he was given Shift Learning, Part G.

G. Shift Learning (if failure on Part F): Choosing the symbol and following written commands.

1. Teacher placed an object (ball, box or cup) on the board and told or prompted child to clean it. Teacher then asked child to choose the symbol corresponding to that action. The choices were clean, give, and one unfamiliar verb. The criterion of success was two correct responses out of three.

2. Same as step 1, but substituting the give-symbol.

3. Same as step 1.

4. Same as step 1, but substituting the give-symbol.

5. Steps 1-4 were repeated with a criterion of one correct response.

6. Teacher placed the clean-symbol and an object on the board. Child had to clean the object correctly on two trials out of three.

7. Same as step 6, substituting the give-symbol.

8. Same as step 6.

9. Same as step 6, substituting the give-symbol.

10. Steps 6-9 were repeated with a criterion of one correct response.

H. Lesson Retention Test after Part G: Lesson Retention Test from Part B was repeated. If child passed (6 or more correct) he went on to Part I. If he did not, he was given Parts G and H again.

I. Two-word sentences. The real ball, box, and cup were placed behind the board, along with a small cloth for cleaning the objects.

1. Teacher placed the symbols clean cup on the board. Child had to choose the correct object (cup), and clean it. Teacher guided child either manually or verbally, for a few trials, if this was necessary. After child began to do the correct motions alone, this step was repeated until child made two correct responses out of three trials.

2. Same as step 1, substituting the symbols clean ball for clean cup.

3. Same as step 1, substituting the symbols give ball for clean cup.

4. Same as step 1, substituting the symbols give cup for clean cup.

5. Same as step 1, substituting the symbols give box for clean cup.

6. Same as step 1, substituting the symbols clean box for clean cup.

7. Steps 1-6 were repeated to a criterion of one correct rather than two our of three.

J. Lesson Retention Test. Each item was given only once. Teacher was not allowed to label the symbols or give any hints to child. Passing score was four or more correct. If child passed, he could then go on to part K, complete sentences. If he failed, he had to repeat Part I.

1. Teacher placed the symbols give ball on the board. Child had to give the real ball to Teacher.

2. Same as step 1, substituting clean box for give ball.

3. Same as step 1, substituting clean ball for give ball.

4. Same as step 1, substituting give cup for give ball.

5. Same as step 1, substituting clean cup for give ball.

6. Same as step 1, substituting give box for give ball.

K. Complete Sentences. In this section child learned the function of teacher and child in the sentence as subjects and indirect objects. The same verbs and nouns were used as in the previous sections. The ball, box, and cup objects were placed behind the board and a cloth for cleaning was available throughout. In addition, an extra child-symbol was available.

1. Teacher placed the symbols child clean child on the board. Teacher then guided child to clean him/herself with the cloth (rubbing the cloth on face or hands). Teacher continued to guide child on each trial, until child began to make the proper motions alone. Then the step was repeated until child made four correct responses out of five trials with no hinting or guiding by teacher.

2. Same as step 1, substituting the symbols child clean teacher for child clean child.

3. Teacher placed the symbols child give box teacher on the board and prompted child to do what the sentence said. Guiding was sometimes necessary at first. This step was repeated until child made one correct response alone.

4. Teacher placed the symbols teacher give box child on the board and waited for 5 seconds. If child tried to give the box to teacher, teacher said "no" and corrected child by taking the box and handing it to child. This was repeated until child learned to wait (for five seconds) until teacher carried out the action by giving the box to child. Waiting 5 seconds was a correct response and was rewarded. After one correct response teacher went on to the next step.

5. Teacher now shifted between steps 3 and 4, not alternating, but keeping the number of the two types of trials approximately equal. Teacher waited 5 seconds after writing either sentence (child give box teacher or teacher give box child). For step 3 a correct response was to give the box to teacher, an incorrect response was to wait 5 seconds. For step 4 the reverse was true. Correct responses were rewarded. Teacher continued to shift between steps 3 and 4 until child made 4 correct responses out of 5 trials. These 5 trials contained both types of sentences, so that child would not meet criterion by responding in the same way (either waiting or not waiting) on every trial.

6. Steps 3-5 were repeated using the sentences child give cup teacher and teacher give cup child.

L. Lesson Retention Test after Part K: Each step was done only once. Teacher used the 5 second criterion where appropriate. A passing score was 4 or more correct responses. If child passed, he would go on the Part M. If child failed he had to repeat parts K and L.

1. Teacher placed the symbols child give ball teacher on the board and waited 5 seconds. If child gave the ball to teacher within this period of time, the response was correct; otherwise it was not.

2. Teacher placed the symbols teacher give box child on the board and waited 5 seconds. In this case the correct response was for child to wait for teacher to give the box.

3. Teacher placed the symbols child clean teacher on the board and waited 5 seconds. The correct response was for child to pick up the cloth and "clean" teacher.

4. Same as step 3, using the sentence teacher clean child. Child had to refrain from responding for 5 seconds.

5. Same as step 2, substituting teacher give cup child for teacher give box child.

6. Teacher placed the symbols child clean child on the board. Child had to use the cloth to clean him/herself in 5 seconds.

M. Spontaneity "Test": The purpose here was to determine whether or not the child could spontaneously write meaningful sentences with the words learned so far. It was not really a "test" since there was no way for child to fail. Teacher went on to the next lesson regardless whether child wrote sentences at this point or not. However this part was a measure of child's progress in learning to use the nonvocal language.

1. Teacher demonstrated how to write a sentence. For example, he placed the symbols Teacher clean cup on the board and then carried out that action.

2. Teacher then took the sentence away, and placed all the symbols used in this lesson next to the board. He then gestured to child to write a sentence. If child wrote nothing, he received a score of "0". If child did write, the score was "1". If child's sentence was an imitation of the teacher this was labeled "I". If he created a new sentence, it was labeled "N".

NOTE: Fast learners had no difficulty learning verbs within the sentence structure: subject, verb, object. Hence they began with 3 and 4 word sentences at the lesson introducing verbs. (See Appendix C Manual, Part II.)

LESSON 6: Verbs: eat and insert. Followed by LESSON 7: nouns; bowl, spoon, fork. Subsequent lessons included same, different, question mark, food; colors, numbers and pronouns. For further detail see Appendices C and E.

FURTHER TECHNIQUES TO FACILITATE VERB LEARNING WITH SLOW LEARNERS

There were 13 children who remained at the two-word sentence stage, involving the verbs give and clean in conjunction with a noun, after many sessions. Seven of these children were then exposed to procedural variations in order to facilitate learning, comprehension, and retention. If facilitation were to occur, the attainment level of the seven could then be compared with the attainment level of the six not given additional variations. One was presented with a third verb sleep; one with a third verb insert; one was given 3 more nouns (bowl, spoon, fork); one was shown pictures of children giving and cleaning; three were presented with enhanced symbols of give and clean, in which the symbols were made more discriminable by having red or yellow 1/4" dots placed on their top surfaces.

PROCEDURES AFTER END OF TRAINING:

(1) RETENTION MEASURES: One week after the end of training all subjects were given tests of retention:

The Post-Training Retention Test was composed of two separate sub-tests; Test I for those subjects who did not progress beyond Lesson #5, and Test II for those who progressed to later lessons (See Appendix F).

Retention Test I: Each symbol previously learned was tested 10 times: five times using Technique I in which the child was shown the object and asked to pick the corresponding symbol and five times with Technique II, where the teacher placed the symbol on the board and the child had to pick the corresponding object. In addition to the symbols already encountered in training, five new symbols (spoon, fork, bowl, boy, girl) were used to assess the effect of representational shapes. In addition, two-word sentences and compounds were included at the end of the test to assess the child's comprehension of word combinations. Only words known to the child were tested for recall.

Retention Test II: This test was composed to two parts. In part I all nouns were tested in the same fashion as in Test I above, except that nouns were tested in sets of six. In Part II, retention was assessed for all other words previously learned. One test item was devoted to each symbol or concept. Items were usually in the form of sentences, and utilized only those nouns passed in Part I. In addition to items designed to test retention of old material, a few new items were also included to assess ability to generalize what had been learned.

(2) RATINGS OF TEACHER/CHILD ATTACHMENT: After retention tests were given, attachment ratings were made. Teachers who had been consistently with a child for most of training, rated how attached they felt to a particular child and how much attachment the child appeared to have for his teacher. Ratings were made on a 5-point scale.

(3) POST TESTING: As detailed above, these tests were given to all subjects from training and control groups, with the exception of those who had left the program.

RESULTS:

OVERALL RESULTS

All who remained in the training program* learned something. There were large differences in amount learned, ranging from one word to 60, and varying from single words to nine word sentences. It was evident within the first few weeks of training that there were large individual differences in rate of learning which were largely, but not always, tied to whether the child's mental age was above or below 2 years. Although other dichotomies are possible, the clearest division for fast and slow learners appeared between the 3 fast subjects and the remaining 25.**

There were large individual differences within the slower group. On the average their MA, speech and attention levels were consistently lower than most of the faster group. For the latter, mean MA was 6.2, mean expressive speech was 3.7 and mean receptive speech 3.0, and attention level 77%. For the slower group, mean MA was 1.9, mean expressive speech 1.5, mean receptive speech 2.2, and mean attention level 59.8%. [See Table 1(b).]

Fast subjects learned a mean of 50 words varying from 44 to 60 and they consistently used longer sentences. Slow subjects learned a mean of 10 words ranging from 1 to 16 words and about half used 2 to 3 word sentences. Because of these differences, which will become even more apparent below, the results of these two groups are separately analyzed and reported.

I. ANALYSIS OF SLOW-LEARNING GROUP

A. LEARNING:

Slow learners attained a mean number of 3.7 lessons, and, as noted above, learned a mean number of 10 words ranging between one to 16 words. But, those who learned the most did not necessarily have the highest mental ages, nor speech levels. ("Highest" is relative since, as was mentioned in PROCEDURE, this largely meant speech at about a normal 5 year old's level, with however less clarity of enunciation.) Four subjects (2 in the training and 2 in the control group) with the highest speech levels, had MA's ranging from 1.8 to 2.4 years. The two training group subjects with MA's of 2.4 and 1.0, learned 5 and 13 words respectively. Indeed the child with an MA of only one year learned to write two-word sentences!

Number of concepts a child understood (receptively) prior to training (as determined by the Concepts Test), was directly related to MA, speech level, and number of lessons the child reached (see Table 2). Those with High-Concept knowledge had a significantly higher mean MA of 5.8 than Low- and No-Concept groups who had mean MA's of 2.2 and 2.0, respectively. Receptive and expressive language, as well as number of lessons reached, also decreased with decreasing concept knowledge. (For more specific detail see Table 2.)

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* Further detail on dropped subjects: see RESULTS IV below.

** In their book on nonvocal training, Deich & Hodges (1977) and (at a Nonvocal Intervention Conference, 1977) Hodges & Deich, briefly discussed preliminary findings of this study and used a different dichotomy there. Final results show clearly that the present dichotomy is more appropriate, since two subjects were previously incorrectly reported as tested on the Leiter, when in fact their MA scores were based on the PPVT.

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Regardless of type of symbol learned, passing an interim retention test (given after a lesson was learned) was significantly and negatively correlated with time to learn. The faster the child learned, the more likely he was to retain the material after the lesson. Respective correlations and probabilities were -.598 at .001, and -.459 at .014.

As noted in PROCEDURES above, the low-functioning children had difficulties in learning, including learning to shift from choosing a symbol when shown an object, to the reverse: choosing an object when shown a symbol. Consequently part of the training involved not only learning to choose a symbol, but where necessary, learning to choose an object. These two choice-patterns were labeled Technique 1, T1, and Technique 2, T2, respectively. Some of the subsequent data analyses consider whether these two techniques had an effect on the child's learning and retention.

Technique 2 was added when the child had difficulty generalizing after having been taught only to: choose-symbol-when-shown object. Since the better learners among this low-functioning group actually got to learning verbs (in Lesson 5), these were the ones who passed the lower lessons without needing specific teaching on T2. Since the adding of T2 indicated learning and generalizing problems on the part of the child, it is not surprising that children who were given T2 in addition to T1, generally spent significantly more sessions in learning a particular lesson, nor that they also required progressively fewer sessions as they succeeded on subsequent lessons (see Table 4). On the other hand, lesson 5 (verbs) presented a difficult learning situation. Thus T2 was added for all subjects after several weeks of exposure to this lesson. (See PROCEDURE.)

B. RETENTION OF SLOW-LEARNING GROUP

Subjects were given the retention test one week after end of training. They were tested on all symbols which had been taught to them, as well as on 5 untaught ones*. The latter were representational symbols: spoon, fork, bowl, boy and girl (Figure 1). The question was whether they would do significantly better on representational symbols which had been taught or, whether by the end of training, subjects would correctly respond to any good representational symbols, whether or not they had been taught.

Retention measure was based on the mean of correct symbol selections, and correct symbol rejections. Thus, the child had both to select, for example, an apple symbol when shown a real apple, and not-to-select the apple symbol when shown non-apple objects. With four items shown at a time, the chance of correct selection was 1/4, and correct rejection 3/4. The mean of these 2 thus meant a 50% chance of guessing correctly (see Appendix F for Retention Test). With 5 sets of 4 items each, the child had a chance of making a maximum of 5 correct responses to each individual symbol and/or object.

Chi-square analysis shows that overall, mean retention levels were significantly above chance (Table 5). This was so for nearly all individual symbols, and regardless of whether T1 only, or T1 and T2 were taught.** There was greater

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* These were untaught for all but one subject who was given the 3 nouns spoon, fork, and bowl in the variations-on-lesson-5 noted above in PROCEDURES.

** Recall that T1 referred to: learning to place symbol to object; and T2: object to symbol.

than chance retention on all symbols, except for child and insert for T1. The five untaught representational symbols, which were also shown to the children at this point were recognized above chance for spoon, fork, bowl, and girl, below chance for boy on T2 (Figure 1).

Mean retention level was consistently higher for taught over untaught symbols whether one compared across representational symbols, or across the two techniques. Mean correct retention on both techniques combined for taught symbols was 56%; for untaught symbols it was 52%. Mean correct retention on representational taught symbols was 57%, and 55% for untaught.

Furthermore, retention level was significantly higher for T1 in comparison to T2 for three symbols: the taught symbols give & ball, and the untaught boy symbol (Figure 1 and Table 7a).

Analysis of retention levels across MA showed that there were significant positive correlations of MA with retention levels for either technique, i.e., the higher the MA, the greater the retention level.

There are some interesting findings if one looks at errors, minutes to criterion, and subsequent percent retained, for different sub-groups of symbols. (see Table 6.) Average percent retention seems to be about the same, in the mid-fifties, whether one looks at the dichotomies of representational/non-representational, foods/non-foods, taught/untaught nouns, or whether one goes from lesson 1 through lesson 5. Errors average about 60 for all but foods and non-foods, in which case errors run 72 and 52 respectively. Minutes-to-criterion are distinctly different for the various dichotomies, requiring fifty-plus minutes for representational, foods, and taught nouns, while for non-representational & nonfoods symbols, the time is 31 & 19 minutes respectively. The surprisingly higher errors and time-to-criterion for the seemingly easier symbols (foods and representational symbols) may relate to the fact that the latter came at the beginning lessons when the subject was still being introduced to this new "language."

If instead of symbol sub-groups, one looks at lessons, one sees that, again, percent correct retention remains in the fifties, ranging from 55.5% to 59.0%, while errors and minutes to criterion fluctuate. The first lesson had the most errors, 257.4, and required the most time-to-criterion, 251.7 minutes. Second lesson involving two nouns referring to persons (teacher & child), was learned fastest, 29.5 minutes, and with fewest errors, 41.2. (Table 6.)

A comparison of children reaching only the first, second, third or fourth lesson in general shows no clear-cut trends, when looking at retention levels and expressive and receptive language. However, here, as noted also previously, one may see that for those reaching only lessons one, two, three, or four, untaught symbols were consistently less correctly responded to, on the retention test, than were symbols which were taught. (Table 8: Note that here the mean scores refer to subjects reaching, but not exceeding a particular lesson. Hence scores here differ from those in Table 6 which consider results for all subjects on a specific lesson, including those who reached a specific lesson and those who also went on to pass another lesson.)

The 13 who reached, and, wholly or in part, learned lesson 5,do show some distinct differences from the 12 others who did not reach lesson 5. Although their retention level is the same, they are different on other variables. They learned the first four lessons significantly faster, requiring a mean of 63.4 minutes on each lesson, in contrast to those reaching lessons 1-4, who averaged 246.8 minutes per lesson. The same contrast may be seen in errors made: children reaching the next lesson 5 made a mean of 84.2 errors on previous lessons, in contrast to those reaching lessons 1-4 who averaged 314.2 errors. It is clear that even if those who only reached lesson 1 were eliminated, mean errors and time-to-learn remained significantly higher for those who never reached lesson 5.

In addition there were significant differences on MA, receptive language and attention. Those who reached lesson 5 had a significantly higher MA, vs. those who did not reach lesson 5, with means of 2.06 and 1.36, respectively. In addition, higher MA and reaching-lesson-#5 were associated with significantly higher receptive (but not expressive) language, and higher attention span. Probability was at <.01 in all cases (see Table 3). Regardless of whether symbols were representational (i.e., looked like the object) or non-representational types, greater exposure was significantly and negatively correlated with MA. That is, subjects with higher MA's required fewer exposures to learn either type of symbol. Pearsonian correlations were -.362 (probability = .038), and -.540 (probability = .003) for the two types (Table 3).

The verb lesson 5 presented two different types of problems: learning verbs per se, and learning to put symbols together in sentences. Since teaching began with word-strings at this lesson (i.e., combining learned nouns with unlearned verb: "Child give apple teacher"), difficulties in combining more than one symbol at a time became evident. [Consequently, as noted in PROCEDURE, initial presentation was reduced from 4-word sentences to one-word (verb) "sentences." Once mastered, the verb-symbol was amplified with an object-symbol, such as "give apple", and then again amplified with a sybject-symbol to create a sentence such as "Child give apple", etc.]

Children who had difficulties learning verbs in lesson 5, and were given enhanced symbols (dots, pictures, and extra verb), did not show a significant increase in retention, in comparison to children not given such enhancement. Results were as follows: 0.60 and 0.55, respectively for Techniques I and II for unenhanced symbols, vs. 0.56 and 0.57, respectively for T1 and T2 for enhanced symbols. Nonetheless, some kind of learning occurred for one child given a third verb, "sleep", to learn. On the Post-Training Peabody Picture Vocabulary Test, this child pointed to a pictured bed and dropped her head on the table, simulating sleep. She had not done this on the Pre-training PPVT.

Seven of the 13 children who went through the verb lesson and whose retention level was particularly high on specific symbols, 64%, were then tested to see if they recognized pictorial representations of symbols which they had been taught. They all were able to choose the pictured symbol to a criterion of 2 out of 3 correct. However, analysis of individual symbols showed that the correct selection of actual vs. pictured symbols was higher in almost all cases. Interestingly enough, for 3 individual children pictures of

symbols showed higher scores; child 1: retention of pictured chip was 88%, vs. 69% actual chip symbol, on Technique 1; child 2: retention on pictured candy was 83%, vs. 76% actual candy symbol, on Technique 2; child 3: retention of pictured vs. actual candy symbol on Technique 2 was 72% vs. 63%. (See Table 9.)

PROBLEMS WITH PROCEDURE AFFECTING RESULTS ON SLOW-LEARNING GROUP

Despite specific instructions on how to train the children, teachers created some variations which resulted in unnecessary extra trials. If, at the beginning of training, the teachers "felt" that the child didn't know the symbol, i.e., he failed on an interim retention test, the teacher arbitrarily gave non-standard trials until he/she "felt" the child knew the symbols thoroughly. These extra trials have been labeled "overlearning" trials and may be seen to occur with decreasing frequency from the first through the 11th symbol of the first four lessons. (See Table 10.) Three children were given more than 200 overlearning trials. Note that neither their retention levels, nor mental ages appear significantly different from children not given such excessive overlearning trials (as reported in prior tables).

II. ANALYSIS OF FAST-LEARNING GROUP

As was noted in PROCEDURE, above, not all symbols were available at the beginning of training. Thus the 3 fast subjects had a somewhat different order of presentation, in the first few lessons only. Figure 2 shows trials-to-criterion for selected symbols on lessons which were the same in content for the 3 subjects. Note that the number of trials required to learn symbols varied from a low of 1 trial for boy and girl for subject BE, to a high of 65 trials for the numbers one, two & three, & "and" for subject MS. Figure 3 shows trials-to-criterion for each lesson. In general, trials-to-criterion cluster between 1 and 25 trials but could reach as high as several hundred. Thus BE learned same & different in 17 trials, while JL required more than 176 trials for the same symbols. Table 11 shows that the total number of symbols learned varied between 44 and 60, of which nouns constituted between 19 and 27 symbols, and verbs between 5 and 9 symbols. Retention was high for these fast learners, with retention level varying between 65% to 80%. Retention here was not only based on correct individual symbol and object selection as with the slow learners. All three fast learners correctly responded to individual symbols, and also carried out acts, finished writing sentences, and responded to untaught combinations, as demanded by the queries and commands written out by the teacher.

Pre- and post-training means on MA, attention span, and expressive and receptive language, did not change significantly in either direction: MA's were respectively 6.2 and 6.1, pre- and post-; attention span was 3.3 both pre- and post; and language level expressive and receptive was respectively 3.3 and 3.2, pre- and post-training.

III. PRE- POST-TRAINING RESULTS

As previously noted, the two control groups results were combined since there were no pre- nor post-training differences, and no treatment differences. Controls on the training unit never saw the symbols because of the overall low-functioning of the unit. Thus no incidental learning was possible.

VOCALIZATION AND SPEECH: No significant changes were noted for either training or control groups when each child's pre- and post-training vocalizations and expressive speech levels were looked at from individual subjects' results.

However there were significant increases, for the training group only, in terms of: (1) increased receptive language, with respective pre- and post-means of 61.72 and 72.92, at a <.03 level of significance: (2) increased level of cooperation (<.03 level) (see Table 13).

MA AND IQ: No significant changes for any group, nor were any expected.

ATTENTION: Although there were no significant group differences in attention level initially, attention level pre- and post- changed significantly for control and training groups, but in opposite directions. Control group significantly decreased in attention level, while the training group significantly increased in level by the end of training. Analysis of covariance, controlling for MA, and t-tests, showing changes within groups, clearly show these differences (see Table 14).

IV. DIFFERENCES IN DROPPED AND RETAINED SUBJECTS

As noted above in PROCEDURE, some children were dropped for a variety of reasons, including illness, transfers and non-responsiveness to training. Comparison shows no difference in MA of dropped children, regardless whether they were in the control or training groups, since the respective MA's were 1.4 and 1.5 years. Nor is there any control vs. training group difference in* years respectively. Note, however, that the difference between dropped and retained subjects is consistently in the direction of lower MA's for the dropped children. This is so because the non-responsive subjects who were dropped, were nonresponsive partly because of their lower level of functioning. Their "lower" was even lower than the low-functioning group which constituted the main training group, as discussed above. IQ's follow this same trend. Dropped children, whether from the training (experimental) or control groups, had lower IQ's than the retained children, with IQ's averaging about 24 for the retained, and about 15 for those dropped. (See Table 12.)

V. TIME SPENT

Time spent with children varied. Mean time spent with all retained children was about 1300 minutes, varying from 900 minutes with control groups, and 1500 minutes for the experimental group. Retained controls had about 45 mean number of sessions, with 20 minutes per session, while retained experimentals were given about 67 mean number of sessions at about 23 minutes per session. The number of teachers working with each child averaged around 6. (For further detail see Table 15.)

Rating of child-to-teacher and teacher-to-child attachment (as rated by teacher) was generally positive. However, the ratings were finally considered too variable, haphazard, and subjective, to be meaningful on the average, despite the Likert scale rating which was applied. Hence report of results and discussion of attachment ratings was considered meaningless.

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* MA's of retained children, since mental ages for the latter were 2.5 & 2.2.

DISCUSSION

LEARNING

It was evident that all twenty-eight children learned something through the training sessions. As mentioned in the Results section, the slow learning group of twenty-five children learned an average of ten symbols, ranging from two who learned only one symbol to the thirteen children, who reached Lesson 5, learning sixteen symbols and simple telegraphic sentences. The faster group of three learned an average of fifty symbols varying from forty-four to sixty symbols, and they consistently used longer and more complete sentences.

These three fast subjects differed significantly on mental age from the twenty-five slow subjects, with the former having a mean MA of 6.2 years, in contrast to the latter's MA of 1.9 years. As noted in the Procedures and Results sections, the IQ scores for the three fast learners were based on the Leiter Scale and the PPVT, in contrast to the slow learners, most of whom were tested on the Kuhlman-Binet. (As noted in Procedures, different tests were used of necessity because of the very different populations available.)* Items on the Kuhlman-Binet are more motor oriented. For example, items from the 12- to 18-month level include such items as whether the child can drink from a cup, eat with a spoon, and spit out distasteful solids. On the other hand, the Leiter taps little in the way of motor abilities, eliminates dependence on verbalization entirely, and instead taps more conceptual abilities. The one child in the slow learner group who was able to respond to the Leiter, was the one who reached the maximum learning level for that group (16 words). It would seem then that mental age is a significant factor in learning this system.

In addition to higher mean mental age, the group of three faster subjects had higher levels of expressive and receptive language skills. They had an average score of 3.7 on our expressive speech measurement, meaning that they spoke simple words and sentences in an unclear fashion. By contrast, the slow group had an average score of 1.5, meaning that they made noises and speech-like sounds. The difference in receptive language skills was not as great; 3.0 for the fast ones vs. 2.2 for the slow. The faster group's attention rating was also noticeably higher than the slow group: 77% vs. 59.8%. That their greater facility with language and higher levels of attention also affected the amount they learned, seems clear and comes as no surprise. Their greater intelligence, attention span, and greater skill in processing language undoubtedly aided them in acquiring the symbol system more rapidly.

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* Previously published preliminary results (Deich & Hodges, 1977, & the Hodges & Deich report at the Nonspeech Language Intervention Conference) incorrectly reported an additional two subjects as having been tested on the Leiter. In actuality, they were tested on the PPVT since neither subject could pass the baseline items on the Leiter.

The children's relationship with, and feelings towards, their teachers also seemed related to the amount they learned. Though our overall ratings of child-to-teacher, and teacher-to-child, attachment were considered to be too subjective and biased to be analyzed statistically, it was evident that many of the children had developed an attachment to one particular teacher (and vice versa). The child tended to perform better and to be less distractible when working with his/her favorite teacher. Towards the end of the project one of the teachers, a favorite of one of our fastest learners, left the project, and it was difficult to get this young boy to respond at any level for a while.

In general the slower group of children tended to be more heavily medicated than the three fast children. Variations in their attention span and learning rates occurred in connection with changes in medication. For example, one girl learned the first two lessons rapidly but, after a change in medication, it was difficult to get her to attend to anything, and it took her months to learn the next lesson.

The behavior of one boy was at first quite puzzling. His attention level seemed to fluctuate very rapidly within each session for no apparent reason. At last one of his teachers noted an interesting pattern. As long as he was not progressing he attended to the situation, but when he was correct he became extremely excited, happy, and distractible. He apparently was unable to handle success in these initial sessions, but later he learned how to cope even in these positive situations.

Despite the large differences between the slow and fast groups, it is important to note the slow group did learn to use the nonvocal system to some extent. When we compare scores for the group of thirteen children who learned verbs, with the group who did not, mental age again seems a factor. Those children who reached Lesson 5 (verbs) had significantly higher mental age (as well as higher receptive speech and attention levels) than those who did not reach Lesson 5. Even though one is looking at fairly low functioning, on the average those with mean MA's of 2.06 reached Lesson 5, those with MA's of 1.36, did not. In general then, mental age seems to relate to mastering the system, as does attention, speech level, and motivation. However, there were exceptions to this. Some subjects with extremely low I.Q.'s were able to reach Lesson 5. Of particular interest was one child who had an IQ of eleven, an MA of 1.6 on the K-B, primitive receptive language skills (the ability to follow a few commands) and essentially only the ability to make noises (nonspeech-like sounds) in the area of expressive language skills. This subject had previously received both speech and signing lesson and had been essentially non-responsive to both, yet in the present system, this child mastered verbs and simple telegraphic-type sentence construction.

When we examine the data for differences between the slow children who learned Lesson 2, 3, and 4 and those who remained on Lesson 1, mental age is no longer a significant factor. One subject with a mental age of one year was able to learn eight symbols, another with a mental age of one year learned five symbols, while three subjects with mental age's of over one year four months remained on Lesson 1. Additionally, two of these three had higher receptive and expressive skills than the two who reached lessons 2 and 3. This is difficult to explain since these subjects did not seem to differ on attention. One can only hypothesize that other factors, perhaps motivational ones not measured by the study, played a part in determining their learning rate.

The difficulty the slower group of children had with Lesson 5 (discussed in both the Procedure and Results sections) seemed also to be related to sentence length and complexity. The children rapidly learned one word telegraphic phrases (give object, insert object) but when confronted by a string of several symbols, they appeared confused, and their response dropped to a chance level.

The children learned concrete nouns more rapidly than the verbs. The original design for learning verbs, which worked well in our original pilot and also with the present three fast subjects, was one of a string of symbols such as, "Child give apple teacher". Since the slow learners were unable to go from single nouns to strings of words which included sentences, we radically reduced what was presented on the learning board. The sentence became a holophrase, such as "give object" (with implied donor and recipient, and with the real object alone being present). Under these conditions the child was able to learn the verb. However, when longer sentences were introduced correct response again tended to drop to a chance level. Thus these children required many mini-steps to begin to learn sentences.

Roger Brown (1974) suggested that children below the age of two years four months are unable to carry out conversations and use sentences, not because they lack the vocabulary, but because they do not have the conceptual skills necessary to plan and execute such a sentence. In other words, a sentence such as "Child give teacher apple" requires that the child must be able to recognize and respond to each symbol, and also to process the sequence in order. The child must recognize that this sentence differs in direction and meaning from "Teacher give apple child", and respond differently. It may be that below the mental age of two such sequenced programming is beyond the logical operation of the child, and we might have to be content with telegraphic sentences from these profoundly retarded subjects.

It is more likely that our methodology erred in introducing stringing and verbs simultaneously for these slow learners. Verbs are more complex, less concrete, and more difficult to learn. By introducing this higher concept class, and by increasing phrase length, processing was made more difficult. It would seem, therefore, that for children at low levels of functioning, i.e., MA of about two years, we introduced too much at one time. A shorter, more concrete introduction to stringing might have produced less confusion.

Nonetheless, based on present data and our previous work, we can conclude that, generally, children who have a mental age above two years can master this nonvocal system. However, when we examine children who have mental ages below two years, there are some extremely low functioning ones (in terms of low mental age, receptive and expressive language skills, and attention span) who do seem to learn the system. Not surprisingly they have even greater learning difficulty, as seen in significantly more errors, and they need even more repetitions. In view of the inability of these low functioning groups to master either vocal language or signing, the use of a symbol system for communication needs seems to be of value, even though learning is so slow. In other words it is better for them to have at least some way of communicating, however primitive, than none at all.

RETENTION

Retention was significantly above chance for symbols each subject had learned. As would be expected from the difficulties in learning the verb lesson, there were more errors on verbs than on other speech parts. The higher error rate on food items probably relates to the fact that such items occur in the first few lessons when the child is first learning the system. In addition, the subjects who reached the later lessons in which nonfood and nonrepresentational symbols were introduced were those who had higher mental ages, receptive speech, and attention levels. These factors also account for the lower error scores on the later lessons, as well as for the lower time to criterion on nonfood, nonrepresentational, and verb symbols. In general, the subjects demonstrated a learning-to-learn phenomenon, with fewer errors and time required to master the later lessons than the first lesson.

Of interest is the high correct level of response to the untaught representational items. It would seem the children learned a general paradigm of matching a symbol to a similar (but not necessarily the same) colored object. In Piagetian (1926, 1952, 1954) terms, the child had learned both the class of signifiers and significant. There is a class of objects, and a class of things that, in some way, resemble these objects (shape, color, etc.) This association of symbol and object was not present at the time of the first lesson when representational symbols were introduced. The children therefore had learned something more general in their training, since they were originally unable to respond correctly to representational symbols. This amount of generalization from such a low functioning group is interesting and demonstrates a learning potential that was actually unexpected. Note, however, that the lower group of slow children (who did not learn the verb lesson and had an average MA of 1.36 years), did not demonstrate this generalization to untaught representational symbols as well as did the "higher" functioning slow group who did begin to learn verbs, and who had an average MA of 2.06 years.

Technique II was introduced for those subjects who had trouble mastering the learning sequence. Although these children had learned to match the symbol to the object, they were unable to match the object to the symbol. As noted in the Procedure section, we had to train for a shift in learning: that is, after teaching that A goes with B, we also had to teach B goes with A. It was necessary to teach the symbol-object and then the object-symbol sequence for each item the child learned. To illustrate, consider Mary's responses. After many treats Mary learned that the apple symbol, , goes with the real (plastic) apple. At that point she reliably (over 80 percent of the time) selected the correct apple symbol from an array of four symbols and placed it in front of the apple. However, when Mary was shown the actual apple and asked to place it next to the apple symbol, , she was unable to do so. This step, which we called a shift, was taught separately. Once she learned this shift, she was taught the symbol for banana, . Again, Mary reliably learned to select the symbol from an array and place it in front of the real banana. When presented with the banana and required to move the banana to the banana symbol, , she was again unable to do this and so had to be taught this shift. In some cases the same procedures had to be followed

for each symbol, regardless how many other symbols and shifts the child had learned. Shift learning seems to be more rapid than the original pairing, but still needs many guided trials. The significantly lower retention level, for children who had to be taught technique II on the first lesson, seems to be related to their lower mental age in comparison to the other children.

It is important to note that the researcher/teacher must be aware of where and when to change teaching techniques to meet the needs of a particular child. Many of the children were able to master this association without specific training. For others, even when the staff initially felt it would be impossible to demonstrate any learning, modifications of the procedure aided the child in learning the particular task. For example, one girl had great trouble learning the object/symbol shift and we despaired of her progressing past the first lessons. After training on shift-learning she went on to learn verbs, used symbols spontaneously with her trainer, and demonstrated generalization to untaught pictures.

Seven of the thirteen children who went through the verb lesson, and whose retention level was particularly high on specific symbols, were then tested on pictures of the symbols they had been taught. The children showed that they recognized these two-dimensional pictorial representations, since they correctly chose pictured symbols to a criterion of 2 out of 3 correct. Nonetheless, recognition of actual symbols was easier, since out of a total of 40 choices (the same 20 symbols were shown once under Technique I and once under Technique II) given to nearly all seven children, only 3 instances showed a higher recognition of pictures over actual symbols.

The important point here is that the children had learned an analog to reading. This makes the system more useful since the child can respond to a two dimensional representation (as on a mural or, in a book of symbols) thus reducing the cumbersome task of carrying around a bag/box of symbols. In this situation the child could then communicate needs and desires by indicating the correct symbol sequence.

FAST LEARNING SUBJECTS

The three faster subjects learned the lessons rapidly. Number of trials to criterion was far lower, amount learned was higher, and retention varied from 65% to 80%. For the higher functioning child the symbol system is a more easily mastered communication technique.

These fast learning children often changed the rules for us. As an example, one child liked to deliberately construct his sentences incorrectly and then just as deliberately corrected them, after which he would calmly reward himself with a reinforcer. Another refused the small candy rewards, but responded well to stars drawn on a piece of paper which could later be turned in for a cheap toy reward.

The rapid learning and extensive use of the symbols these 3 children demonstrated added to the enthusiasm of the teacher-trainers. The evident learning and ingenuity one child displayed can be seen in the following example. He had an apparent aversion to the word "No" and when asked a

question requiring a "No" response such as "Red color of (blue) box?" he would exchange the color symbol so the sentence would read "Blue color of (blue) box?" in order to respond "yes".

PRE-POST DIFFERENCES

Unlike previous reports (Carrier, 1974) there was no significant increase in vocalization from pretraining to post-training sessions. This may be due to the extremely low level of functioning in both mental ages and speech that characterized most of our subjects. It is difficult to ascertain population characteristics of other studies from the descriptions given in the literature. Our training group did show increased receptive language skills, increased level of cooperation, and increased attention span. We did not predict, nor did we find, any changes in concepts, mental age, nor IQ.

Although no significant changes in expressive language were found, there were qualitative changes in the language of those children who had some words. As an example, one girl at the beginning of the study would say (to herself) "Cathy bad girl", and hit herself. By the end of training she no longer hit, had begun to smile, and would say "Good, Cathy, good girl". In general, children in the training group showed increased positive behaviors, and less acting-out destructive behaviors, according to caretakers who interacted with them on a daily 24-hour basis.

It is interesting to note the significant changes that occurred for control and training groups on pre- and post-test attention-span scores. The training group increased significantly in attention span, while the control group decreased significantly The increased attention span for the training group was hypothesized, but the decrease for the control group was not. Perhaps the non-contingent social reinforcement without task direction produced this effect. Our teacher-trainers also felt the control children had become bored, and this may well have led to decreased attention span.

DROPPED SUBJECTS

As noted in the Procedures and Results section, the children who were dropped from the study tended to be those with unworkable behavioral problems, lower MAs, and other disabilities. As an example, one girl who was dropped from the study was painstakingly taught to grasp objects, so that she would be able to manipulate the symbols. Unfortunately, the grasping behavior was extinguished by staff members who felt it was inappropriate in other situations. Rather than start all over again with this child, we decided to concentrate on other subjects.

Most of the children came to enjoy the training sessions to such an extent that sometimes the staff caretakers would unfortunately use the session as a goad to good behavior, i.e., "if you're good you can go, if you're bad you can't go to the session today." Despite their apparent eagerness to come to the sessions, the children responded differently to different teacher-trainers and for different rewards. As noted with the high functioning group, the slower ones, too, sometimes devised their own reward system, varying from

M&M's, to cereal, apple slices, Kool Aid, music, etc. One boy wanted his juice from a doll bottle so that he could reward himself after each correct action.

This project featured control groups lacking in previous work, including our pilot study. The matched controls who received one-to-one interaction but no training, shared a decrease in attention and no increase in language skills. Thus it seems that it is the symbol system itself which facilitates increased attention, as well as some measure of skill with plastic symbols.

CONCLUSION

The symbol system seems to have promise for the nonvocal retarded child who has problems in communication. For even the profoundly retarded child the system is of value, although with very low MA's, i.e., below 2 years, one can generally expect much slower and more limited learning than for children who have MA's above two years. Thus the system can even be used with children who have a mental age of one or over, although those with higher mental ages and some simple receptive language skills, and few behavioral problems, will learn the system more rapidly. If a child can be taught vocal language or signing it is certainly preferable to the more cumbersome symbol system. However, both speech and signing involve a temporal mode and require adequate short-term memory, which the symbol system does not require. In the symbol system the stimulus material remains visible until the child is ready to respond, so that the deficits in short-term memory which characterizes the retarded population is of much less importance. Hence, where other modes of communication cannot be taught, or when pre-speech stimulation is desirable, then a nonvocal symbol system may well be the preferred communication approach.

In reviewing the conceptual and perceptual prerequisites for language (Clark, 1974), we noted that our population has the perceptual skills necessary for mastering the Premack system: they can discriminate and respond to shape, size, and movement; none are deaf, and they respond to sound (although hearing is not a requisite for this system); they also respond to taste, having a hierarchy of food preferences; responses to texture and touch have also been observed. Children having perceptual deficits in these areas may not respond to training in the system.

From the Piagetian view of language (1926, 1952) a child must first learn to understand the class of objects prior to developing the representation for the object. Premack has commented that in initial training the chimp does not distinguish the referent from the thing to which it refers, and so it smears a piece of apple on the board rather than placing the symbol representing the apple on the board. All of our subjects seemed to distinguish the class of real objects from the class of symbols. None of the children, not even the low functioning group, have attempted to place the object instead of the symbol on the board, so, perhaps, they are in some sense preprogrammed for language. Interestingly enough, the children tend to put the symbols representing food items into their mouths, but we have not noted any mouthing of nonfood symbols.

So far as we know, no other study except our ongoing one has adequately compared the relative facilitative effect of symbols plus one-to-one interaction, vs. comparable one-to-one interaction without learning symbols. As noted above, the symbol system has advantages in that it exists in two modalities, time and space, and permits different types of sensory inputs (visual and tactual). For the child with difficulties in processing and sequencing language, or for the child with difficulties in fine motor coordination, these additions may permit him to learn more readily than would, let's say, a signing system. If words were individually selected for each child and environmental controls were such that mastering a symbol produced an immediate real world environmental effect, one might increase the child's learning. In classrooms or at home, where parent or teacher has more time and can be consistently with the child, learning under those conditions might progress more rapidly and be even more meaningful to the child.

Our work has confirmed that symbol systems can be valuable in training nonverbal retardates to communicate, even if such communication is only partial, as is the case with some subjects. Others, such as our higher functioning children, seem to learn the system fairly readily. Indeed they even learn syntactical order without any direct teaching, and are able to progress from one-symbol labeling to stringing fairly long and complex chains.

TABLES AND FIGURES

Table 1: Subject Characteristics: (a) of original subjects; (b) of retained subjects

(a) Characteristics of original subjects

	n	CA	MA[a]	IQ[a,b]	SPEECH LEVEL EXPRESSIVE	SPEECH LEVEL RECEPTIVE	ATTENTION LEVEL %
Experimentals	33	13.3	2.0	18	2.5	2.4	62.1
Controls	20	11.8	2.7	25	2.5	2.4	69.4

(b) Characteristics of retained subjects

	n	MA	SPEECH LEVEL EXPRESSIVE	SPEECH LEVEL RECEPTIVE	ATTENTION LEVEL %	# SESSIONS	# LESSONS REACHED	# SYMBOLS LEARNED
All experimentals	28	2.5	1.7	2.3	62.6	57.7	5.6	14.3
Fast S_s	3	6.2[c]	3.7	3.0	77.0	56.4	21.3	50.0
Slow S_s	25	1.9[a]	1.5	2.2	59.8	57.8	3.7	10.0
All controls	18	2.2	3.2	2.0	69.0	----	----	----

a - based on Leiter, PPVT, K-B, or S-B

b - IQ's per test as follows:

	Leiter	PPVT	K-B	S-B
Exper.	43	34	11	29
Contr.	41	23	14	25

c - based on Leiter Scale

Table 2: Relationship of Concept Knowledge to MA, Speech Level, # Sessions, and Lessons Reached

CONCEPT GROUP		n	MA	SPEECH		# SESSIONS	LESSON REACHED
				EXPRESSIVE	RECEPTIVE		
High (9-14 concepts)	Exp.	3	6.2	3.7	3.0	564	21.3
	Control	2	4.2	3.3	3.0	---	----
Low (1-8 concepts)	Exp.	6	2.0	2.1	2.8	55.5	4.5
	Control	2	2.2	3.5	3.0	---	----
No (No concepts)	Exp.	19	1.8	1.3	2.0	58.6	3.5
	Control	14	2.8	2.4	1.7	---	----

NOTE: 4 S_s in Experimental and 2 S_s in Control Groups showed same post-test improvement on concepts.

Table 3: Comparison of Subjects Reaching, and Not Reaching Lesson 5 on MA, Receptive Language, and Attention Level*

	n	MA	RECEPTIVE LANGUAGE	ATTENTION LEVEL %
S_s Reaching Lesson 5	13	2.06 ±.16	79.54 ± 8.50	68.08 ±5.33
S_s Not Reaching	12	1.36 ±.08	42.42 ±10.77	50.83 ±3.88
t		3.91	2.70	2.62
Significance level		.0005	.0065	.008

* Only significant results from t-tests reported. Differences between other variables not significant.

Table 4: T-tests on Number of Sessions Required on First 4 Lessons for S_s given one or both Techniques,(T1 and/or T2)

LESSON LEARNED	N	T1 & T2	N	T1 only	t	SIGNIFICANCE LEVEL
1	4	52.25 ±10.00	21	33.57 ±4.6	1.69	.083
2	4	11.00 ± 2.94	17	5.59 ±0.99	1.74	.078
3	8	15.63 ± 2.04	10	7.50 ±1.12	3.49	.003*
4	15	11.73 ± 1.64	2	1.00 ±0.00	6.53	.000*

* = significant (at <.05)

Table 5: Chi squares for Retention Levels for All Symbols

	RETENTION %		
	≤50%[b]	>50%[a]	
O	319	397	
E	358	358	
x^2			8.49[b]

a = mean of correct selections & rejections, chance = 50%

b = <.01 probability

Table 6: # Errors, Minutes to Criterion, and % Correct Retention for Different Symbol Groups, and within Lessons 1-4.

SYMBOLS		ERRORS	MINUTES TO CRITERION	% RETAINED*
NOUNS				
Representational[a]		60.37	52.43	56.7
Non Representational		60.06	31.153	56.4
NOUNS				
Foods[b]		72.26	58.89	57.3
Non Food		51.63	19.85	55.5
REPRESENTATIONAL				
Taught Nouns		60.37[c]	52.43[c]	56.7
Untaught Nouns				54.9
LESSONS	# SYMBOLS TAUGHT			
1	3	257.4	251.7	59.0
2	2	41.2	29.5	59.0
3	3	141.3	65.2	55.5
4	3	173.4	50.9	55.6

a - apple, banana, cup, ball

b - apple, banana, cereal, chip, candy, food

c - includes data on 1 S taught spoon, fork, dish

d - spoon, fork, bowl, boy, girl

* Based on X correct selections and rejections.

Table 7: Retention Levels on Both Techniques Across Selected Variables*: (a) Symbols, and (b) MA.

(a) T-TESTS ON SYMBOLS AND TECHNIQUES*

SYMBOLS	% CORRECT RETENTION TECH I	% CORRECT TECH II	T	SIGNIFICANCE LEVEL
Give	63.5 ±4.9	53.5 ±3.0	1.82	.045
Ball	60.9 ±3.2	42.3 ±4.2	2.18	.023
Boy	60.2 ±2.9	47.9 ±2.1	3.75	.0005

(b) PEARSON CORRELATION COEFFICIENTS* ON RETENTION**: MA & TECHNIQUES

	TECH I	TECH II
MA Correlation	0.808	0.752
Significance	0.049	0.010
n	(5)	(9)

* Only significant results are reported

** Based on mean correct selection and rejection

Table 8: Mean Retention Levels[a] on Techniques (T1, T2) and Taught & Untaught Symbols, together with Speech Level, Errors, & Minutes, per 5 Lessons. (Note: Mean scores refer to subjects who reached, but did not exceed, a specific lesson. Hence these scores differ from Table 6.)

	PERCENT RETENTION												
LESSON REACHED	T1			T2			T1 & T2		SPEECH LEVEL				MINUTES-TO-CRITERION
	TAUGHT	UNTAUGHT	n	TAUGHT	UNTAUGHT	n	TAUGHT	UNTAUGHT	EXPRESSIVE	RECEPTIVE	ERRORS	n	
1	56	56	3	55	49	2	57	54	1.3	2.0	616.8	4	411.0
2	68	61	2	57	45	1	67	57	2.3	1.7	253.7	3	257.2
3	56	52	2	56	53	2	56	53	2.0	1.0	115.8	2	123.0
4	55	51	3	54	52	2	54	51	1.7	1.3	270.5	3	196.1
5	58	59	13	56	53	13	57	57	2.0	2.8[b]	173.6[c]	13	77.2[d]
SUBJECTS REACHING LESSON													
1-4	58	55	10	55	50	7	58	53	1.8	1.6	314.2	12	246.8
5	58	59	13	56	53	13	57	57	2.0	2.8	173.6	13	77.2

a = based on mean correct symbol selection and rejection

b = n = 12

c = this group showed a mean of 84.2 on lessons 1-4

d = this group showed a mean of 63.4 on lessons 1-4

Table 9: Retention Level for Actual Symbols vs. Pictures of Symbols

	PERCENT RETENTION							
	TECHNIQUE 1				TECHNIQUE 2			
SYMBOLS	ACTUAL SYMBOLS	n	PICTURES OF SYMBOLS	n	ACTUAL SYMBOLS	n	PICTURES OF SYMBOLS	n
Apple	76	5	56	5	70	1	34	1
Banana	75	4	48	4	64	1	66	1
Cracker	76	1	56	1	68	1	66	1
Teacher	72	3	46	3	80	3	50	3
Child	--	-	--	-	--	-	--	-
Candy	73	4	71	4	67	2	55	2
Chip	72	1	35	1	72	2	55	2
Cereal	--	-	--	-	76	1	50	1
Ball	71	3	50	3	64	1	50	1
Box	71	3	51	3	64	1	50	1
Cup	--	-	--	-	70	1	44	1
Give	81	3	48	3	--	-	--	-
Clean	86	2	56	2	--	-	--	-
Insert	--	-	--	-	65	1	50	1
Sleep	81	2	69	2	--	-	--	-
Spoon	70	2	56	2	80	1	54	1
Fork	71	2	46	2	--	-	--	-
Bowl	63	1	52	1	66	1	33	1
Boy	--	-	--	-	--	-	--	-
Girl	71	3	41	3	--	-	--	-

NOTE: In 3 individual instances, pictures of symbols had higher scores: T2: chip 88% vs. 69%; T1: candy 83% vs. 76%; and 72% vs. 63%.

* Mean of correct symbol selections and rejections.

Table 10: (a) Overlearning Trials & Errors Per Symbol (Lessons 1-4); & (b) Retention Level for the 3 $\underline{S}_s$ Given More than 200 Extra Trials (Lesson 1).

(a) EXTRA TRIALS ON SYMBOLS IN LESSONS 1-4

APPLICABLE SYMBOLS	$\bar{X}$ OVERLEARNING TRIALS	$\bar{X}$ ACCOMPANYING ERRORS
Apple	126.3	78.56 ±19.7
Banana	63.0	82.28 ±29.1
Cracker	36.9	95.72 ±27.5
Child	9.3	22.48 ± 8.2
Teacher	11.1	12.16 ± 4.5
Candy	9.4	42.20 ±11.3
Chip	10.3	38.00 ± 9.5
Cereal	4.5	30.24 ± 8.1
Ball	1.6	29.92 ± 8.2
Box	1.5	45.68 ±10.9
Cup	1.8	46.72 ±13.8

(b) MA & RETENTION LEVELS FOR 3 $\underline{S}_s$ Given More than 200 Overlearning Trials on Lesson 1 Only

		% RETENTION*		
S	MA	APPLE	BANANA	CRACKER
SF	1.6	53	56	56
DH	1.6	51	50	56
KJ	2.3	53	60	58

* $\bar{X}$ correct symbol selection and rejection.

Table 11: Learning and Retention for 3 Fast Subjects

	JL	MS	BE
LEARNING:		# CORRECT SYMBOLS	
SYMBOL TYPE			
1. All (nouns, verbs, adjectives, etc.)	46	60	44
2. Nouns	19	27	20
3. Verbs	7	9	5
RETENTION:			
# errors	11	12	16
% errors	24	20	35
% correct retention	76	80	65

NOTE: All taught, individual, symbols were passed on Retention Test, except for one noun by subject MS. Errors on Retention test were in response to sentences and/or untaught symbol combinations.

Table 12: Comparison of Original, Dropped and Retained Subjects in the Two Groups (Experimental and Control) on CA, MA, and IQ.

				IQ			
	n	CA	MA	Leiter	PPVT	K-B	S-B	$\bar{X}$
Original S_s								
Exper.	33	13.3	2.0	43	34	11	29	18
Control	20	11.8	2.7	41	23	14	25	25
Retained* S_s								
Exper.	28	12.7	2.5	43	33	12	27	21
Control	18	11.8	2.2	41	24	15	26	27
Dropped S_s								
Exper.	10	14.9	1.5	--	35	9	36	13
Control	4	11.8	1.4	--	20	11	25	19

*Includes S_s added to program

Table 13: Pre- and Post-Training: Significant Changes on Receptive Language and Cooperation: T-test Results

VARIABLE	$\bar{X} \pm$ S.E. PRE	$\bar{X} \pm$ S.E. POST	t	SIGNIFICANCE LEVEL
% Correct receptive speech	61.72 ±7.67	72.92 ±5.53	2.07	.025
Cooperation	1.95 ±1.39	2.23 ±0.09	2.03	.028

Table 14: Attention-Span Change from Pre- to Post-Training:
(a) Analysis of Covariance Across Groups; (b) t-tests Within Groups

(a) Attention-Span Change Across Groups*: Analysis of Covariance**

MONTHS	GROUP	ATTENTION SPAN CHANGE $\bar{X} \pm$ S.E.	F	SIGNIFICANCE LEVEL
Feb-Oct.	Exper.	0.50 ±.26	4.98	.03
	Controls	-1.40 ±.48		

(b) Attention Span Change Within Groups*: t-tests

MONTH	GROUP	ATTENTION SPAN CHANGE $\bar{X} \pm$ S.E.	t	SIGNIFICANCE LEVEL
Feb.	Exper.-Post-training	3.13 ±.18	1.90	.04
Oct.	Exper.-Pre-training	2.67 ±.23		
Feb.	Control-Post-training	1.47 ±.42	-2.94	.005
Oct.	Control-Pre-training	2.87 ±.31		

* Excluding 3 fast subjects

** Controlled for MA

Table 15: (a) Time Spent with Subjects, (b) # Teachers/Child

(a) TIME

GROUPS	TIME IN MINUTES $\bar{X} \pm$ S.E.	# SESSIONS $\bar{X} \pm$ S.E.	MINUTES/SESSION $\bar{X} \pm$ S.E.
ALL			
Retained S_s	1284.07 ±92.29	57.81 ±3.39	21.95 ±.65
Retained Experimentals	912.00 ±85.95	44.94 ±4.06	20.32 ±.68
Retained Controls	1537.08 ±120.44	66.56 ±4.19	23.06 ±.93
ALL S_s: (New, Dropped, Retained)	1135.93 ±83.38	52.71 ±3.06	20.83 ±.69

(b) # Teachers/child = $\bar{X} \pm$ S.E. = 6.38 ±.53

Figure 1: Mean Percent Retention Level of Slow-Learning Group

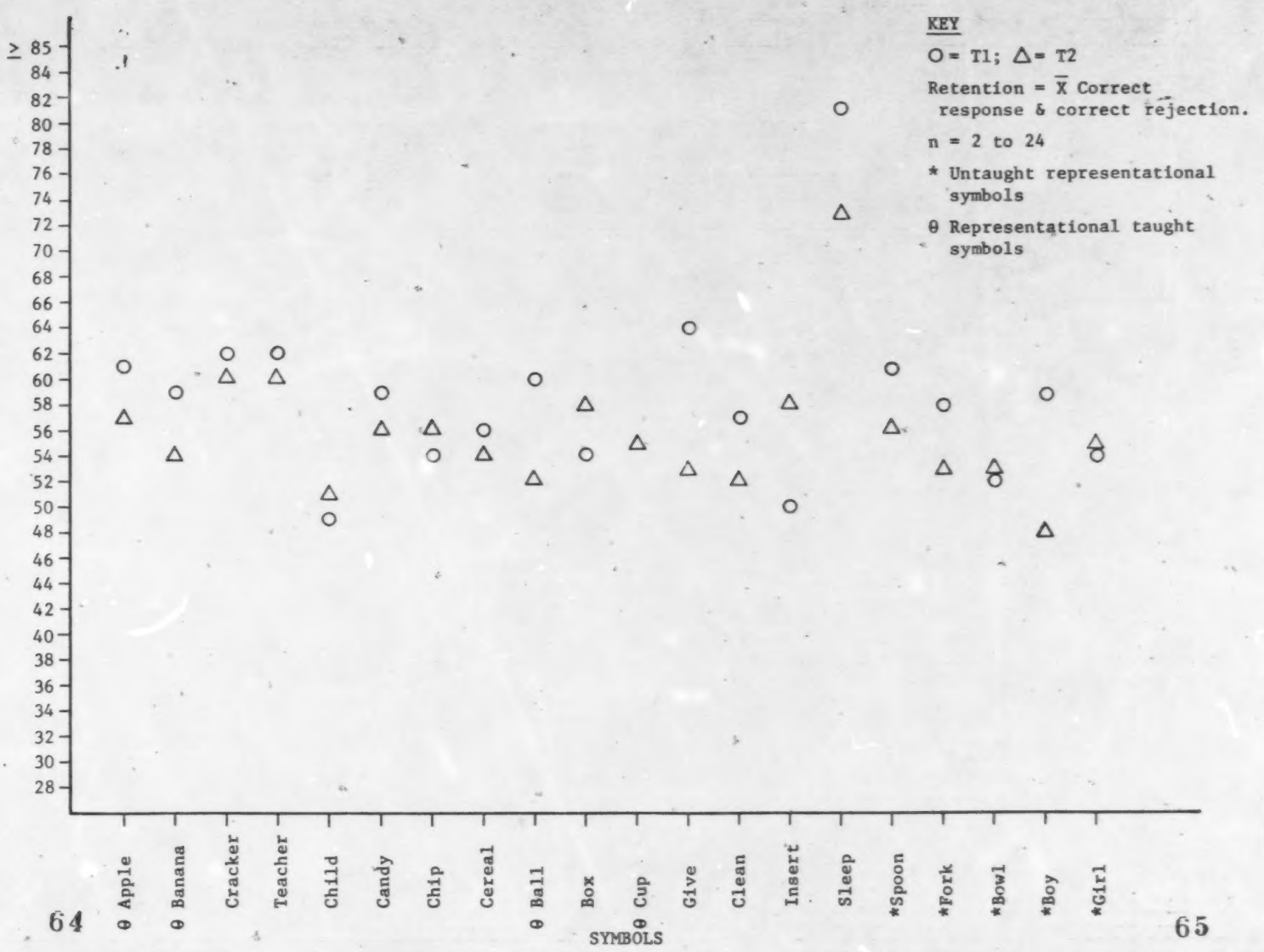


Figure 2: Trials-to-Criterion for Same-Content Lessons: Fast Learners

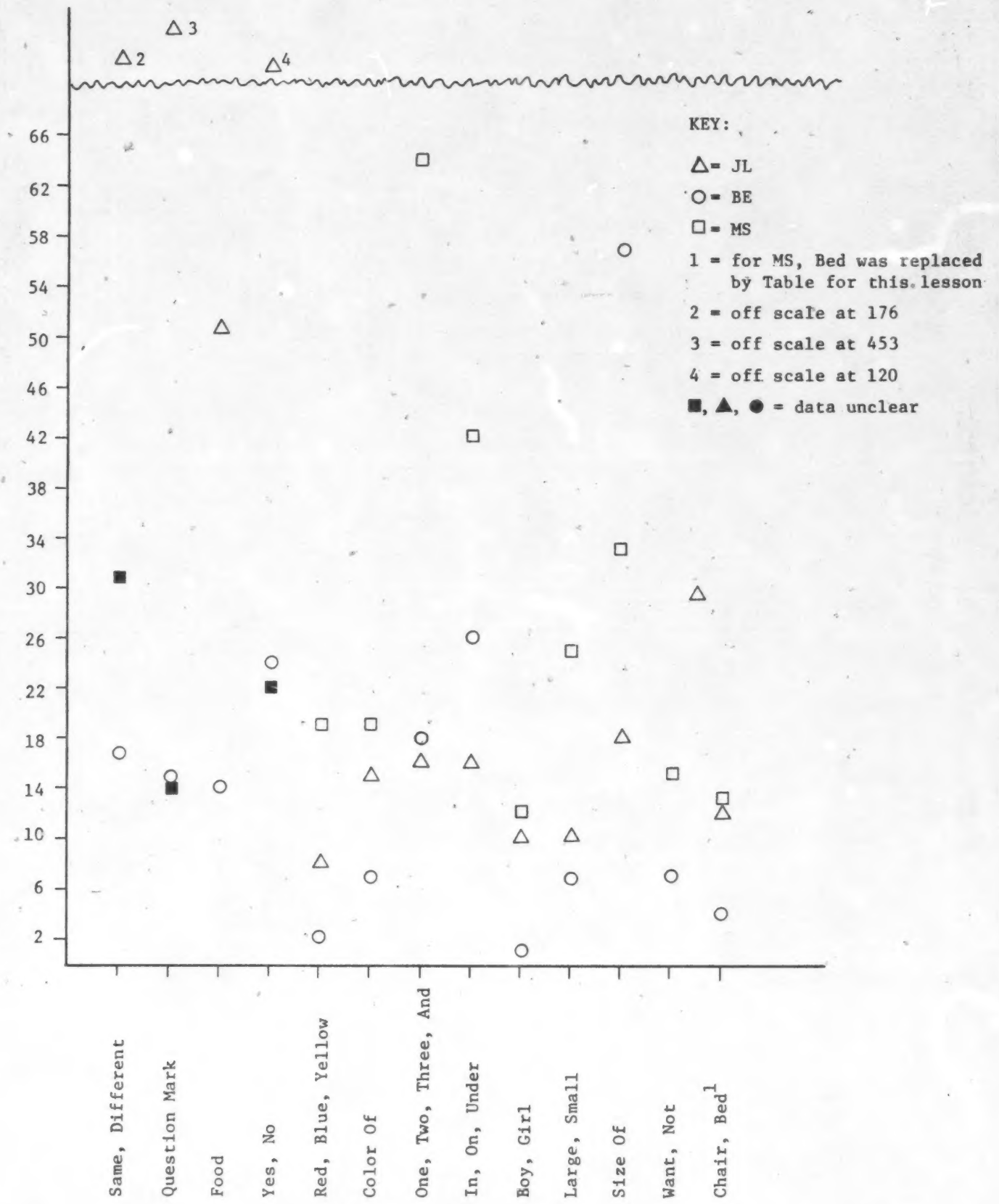


Figure 3: Trials-to-Criterion for Each Lesson; 3 Fast Subjects

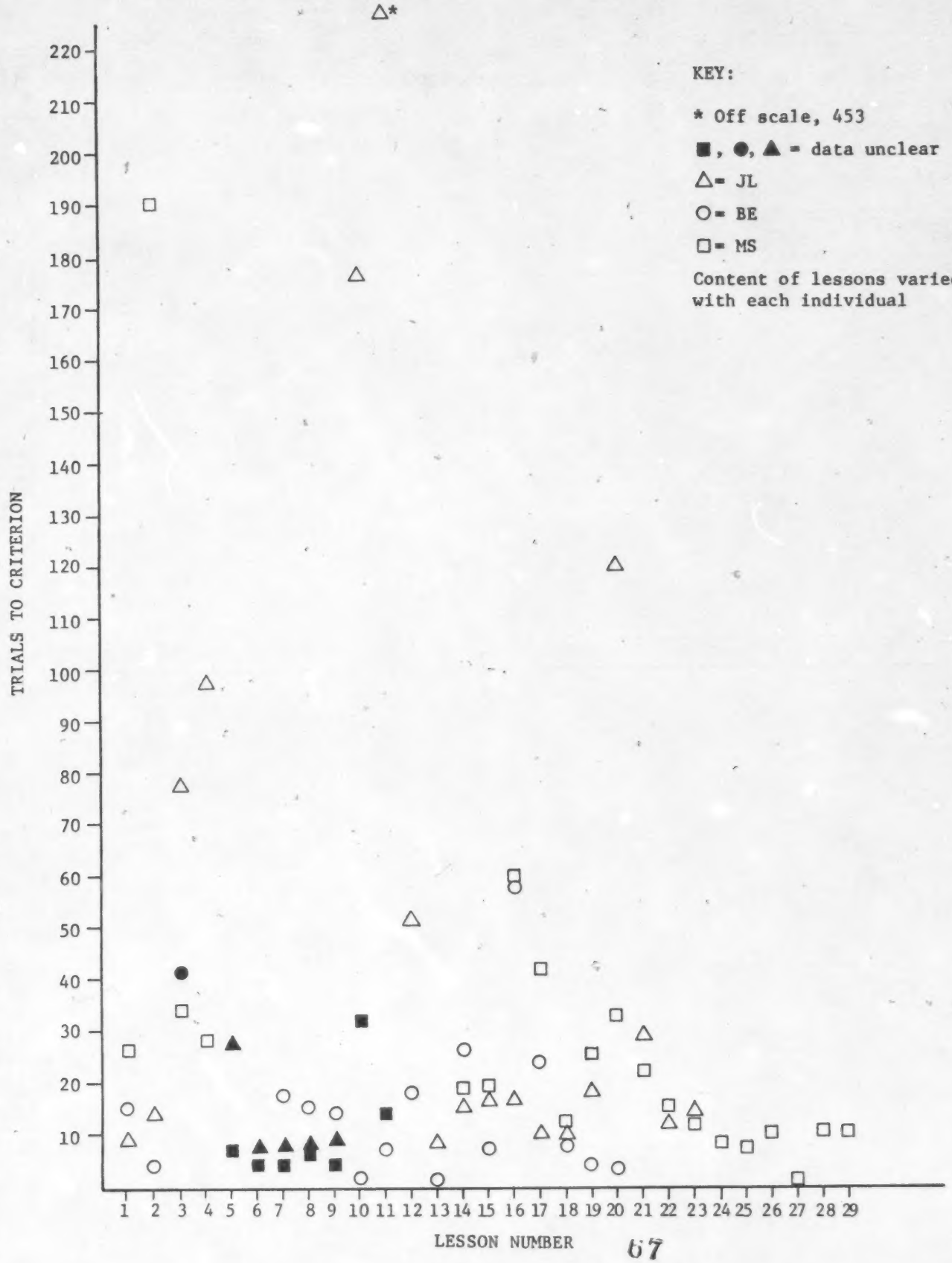
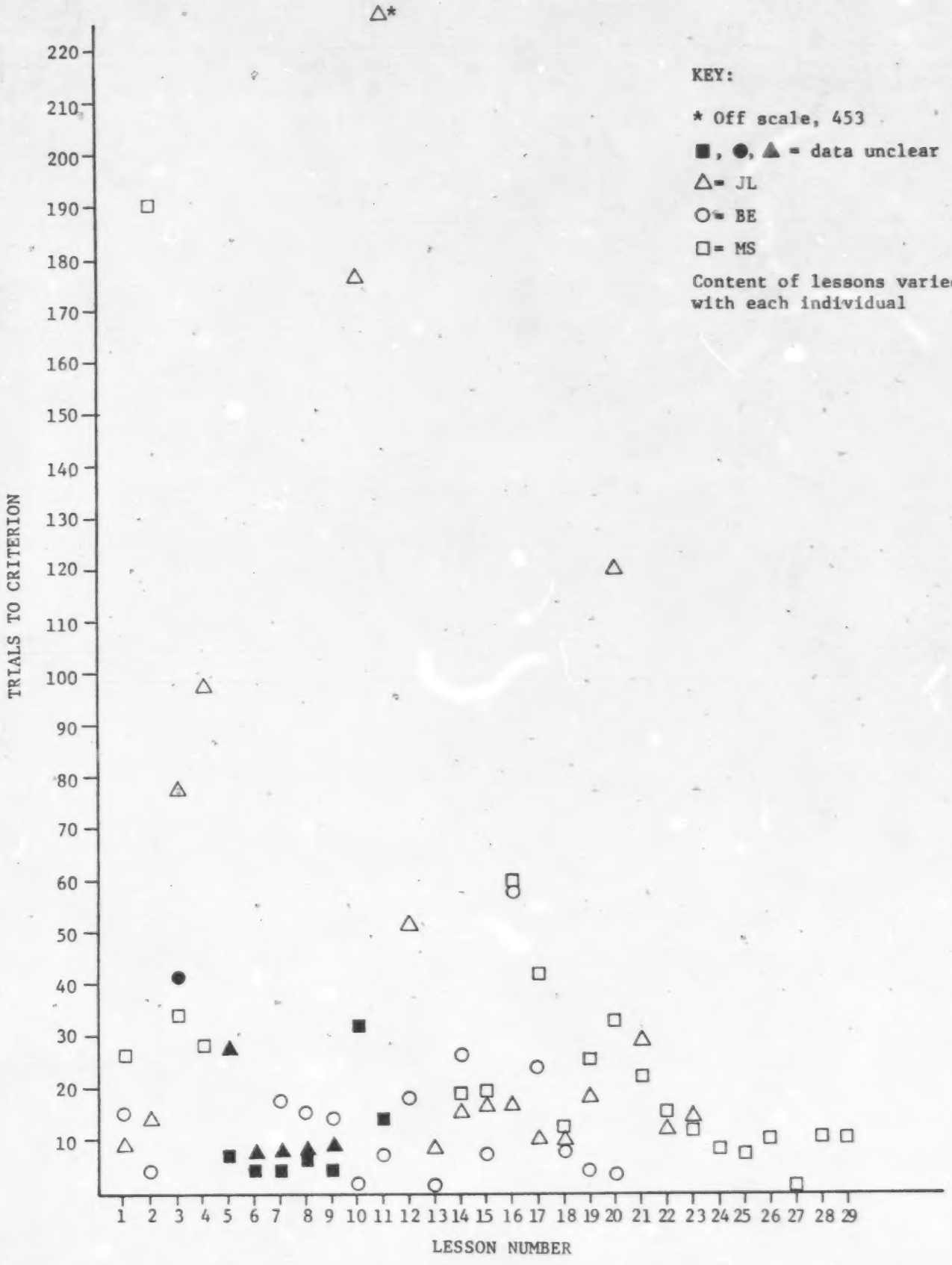


Figure 3: Trials-to-Criterion for Each Lesson; 3 Fast Subjects



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